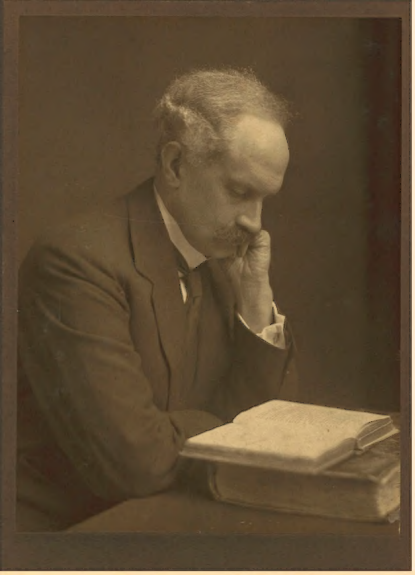

SIR JOHN GRAHAM KERR

AND THE FLOURISHING OF GLASGOW ZOOLOGY

The Glasgow Naturalist Volume 28 Supplement 2024
Published by the Glasgow Natural History Society

Glasgow Natural History Society

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The Glasgow Naturalist

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Front cover (Top) John Graham Kerr reading at his desk; (Bottom) The front aspect of the Graham Kerr (Zoology) Building. (Photos: courtesy of University of Glasgow School of Biodiversity, One Health and Veterinary Medicine)

Back cover (Top) The Zoology Museum in modern times (Photo: M. Reilly); (Middle) Celebration of the building's centenary, November 2023 (Photo: A. Wilson); (Bottom) Centenary celebration, November 2023 (Photo: A. Wilson).

The Glasgow Naturalist
Volume 28 Supplement

Edited by: J. Roger Downie & Iain C. Wilkie

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PREFACE

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This volume celebrates the history, development and flourishing of research and teaching in Zoology and related subjects at the University of Glasgow since the opening of the Zoology Building in 1923. Zoology is, and continues to be, an eclectic subject. It seeks to characterise and understand the diversity of animal life at all biological levels, reaching upwards from the molecules through to cells, individuals, populations, species, communities and ecosystems. The concept of a "model" species is not one that a zoologist can easily embrace. Rather, zoologists revel in differences, recognising that each species has its own unique history, and that its form, distribution and abundance change through time and space in response to environmental challenges. At the core of Zoology is the scaffold provided by evolutionary theory.

While Zoology as a named Department in the University of Glasgow no longer exists, the subject is still very much part of the life sciences research and teaching portfolio. Indeed, Glasgow is one of only a few Universities that has retained a Zoology degree, the various attempts to give the subject a "catchier" name having been valiantly resisted. The degree remains immensely popular with undergraduate students. As in other sciences, research areas rise and fall in their topicality and perceived importance. They come to the fore, fade and often revive, as documented in the descriptions of various areas in this volume. For example, animal taxonomy has risen in importance again as we urgently seek to measure biodiversity, whilst we chart (and hopefully halt) its decline in the face of the rapid changes to the climate and habitats that we have brought upon the Earth.

The contents of this volume romp through the years, with the various authors, myself included, giving their personal takes on the history and development of particular aspects of teaching, research and associated facilities. A defining feature of life in the Graham Kerr Building, amidst the fires and floods of recent years, has been the collegial, co-operative and "can-do" atmosphere created by those who work there. Staff and students now come from many different countries, and the ethos of Equality, Diversity and Inclusion is inspiringly led by Professor Heather Ferguson and others. Not for nothing was the current School given a Silver Athena Swan Award in recognition of its work in promoting gender equality for all.

Scientists we may be but dour we are not. Lots of fun is had in the Graham Kerr Building. Neil Metcalfe has literally faced the music, morphing the diverse local talent each year into an accomplished Christmas band. Jason Matthiopoulos developed our very own rockstar-studded Black Fox band, that provides an in-house gig every so often in the Zoology Museum, sometimes alongside other bands linked to the building. The animals hanging from the museum ceiling literally shake their heads, no doubt in wonder, and the post graduate-led Friday Fox bar plies its trade. Everyone has a good time. Probably no other section of the University has had its own beer, brewed for the centenary celebration of life in the Graham Kerr Building. I'd like to also thank Roger Downie for his dedication and drive in whipping everyone into shape to produce this fine historical record. Read all about it!

EDITORIAL INTRODUCTION

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This volume has its origins in discussions held in 2022 on how to mark the centenary of the 1923 opening of the University of Glasgow's Zoology building, now named after its founder, John Graham Kerr (JGK), Regius Professor 1902-1935. Fifty years before, in 1973, the building's 50th anniversary was the occasion for a dinner and the internal publication of a pamphlet containing short articles on Glasgow Zoology's history to date. For the centenary, the organising team (Pat Monaghan, Neil Metcalfe, Roger Downie, Maggie Reilly, Mike Rutherford and Jennifer Crawford) decided on a number of events and activities, but also that the occasion was a suitable opportunity to put together a substantial historical account. The team approached the funding and publications representatives of Glasgow Natural History Society, who agreed that a Supplement to *The Glasgow Naturalist* would be a suitable publication vehicle for this history, testifying to the close links between the Society and the University.

It was easy to decide on some of the major contributions to this volume: JGK had written a memoir after his retirement from Parliament (where he had represented the Scottish Universities), but this had not been published, despite the efforts of his widow. The memoir, with explanatory notes, is the most substantial component of the book. Annotated versions of the 1973 articles are also included. While the book was being assembled, we were sent a set of notes made by a student from JGK's lectures in 1917, and these make a fascinating contribution, along with a contextual commentary. The major new writing in the book includes Maggie Reilly's history of the Hunterian Zoology Museum and its contributions to the work of the department, and a score of short articles on the different aspects of Glasgow Zoology as they have evolved over a century, including many of the people involved.

We are very grateful to all the authors who so willingly responded to our requests, sometimes at short notice as we remembered topics worth including. We hope that readers find the contents of this book as interesting as we did. We would like to thank all who helped put this volume together, especially Lorna Kennedy, Nathan Miller, and Ruth Maclachlan who formatted all the articles according to *The Glasgow Naturalist* style.

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Sir John Graham Kerr's *A Gallery of Memories*

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ABSTRACT

A Gallery of Memories is a previously unpublished memoir by John Graham Kerr (JGK). In this contribution we provide the memoir itself, preceded by an editorial introduction, which describes the source of the manuscript and gives some information on how it has been edited. It also gives a brief account of JGK's family, publications and career. *A Gallery of Memories* is in four parts. First, *Early Years, 1869-1892*, covers JGK's upbringing, including his studies as a medical student at the University of Edinburgh, his first expedition to the Gran Chaco region of South America (1889-91), and his subsequent decision to switch his studies to natural sciences at the University of Cambridge. The second part, *Cambridge, 1892-1902*, covers his undergraduate studies, then his employment as a demonstrator, including the second more successful Gran Chaco expedition (1896-7) in the company of J.S. Budgett, aimed at collecting embryological specimens of the lungfish *Lepidosiren paradoxa* and the beginning of his researches on this material. Part three, *Glasgow, 1902-1935*, describes his appointment to the Regius Chair of Natural History, then Zoology, at the University of Glasgow, and gives an account of his career and interactions there over three decades. The final part, *Westminster, 1935-1950*, gives an account of JGK's election as Member of Parliament for the Scottish Universities, his resignation from the University of Glasgow, and his experiences in Parliament, including the main issues he attempted to influence, such as military camouflage. We have added an Appendix that provides notes aimed at contextualising many of the people, events and topics covered in the *Gallery*.

EDITORIAL INTRODUCTION

A Gallery of Memories was written by John Graham Kerr (JGK) during his final years, following his resignation from Parliament, and after the completion of the book on his Gran Chaco adventures (Kerr, 1950). He died on 21st April 1957. The source of the typescript of the *Gallery* in the University's possession is a donation in November 1993 made by Elizabeth Gordon of Crieff, sister to Agnes "Nora" Miller, long-time zoology lecturer in the University, who died in 1994. Agnes had asked that her sister donate the bound typescript, dated 1967, to the University's Archives, stating that only three copies are in existence. In another letter of 1965, she states that the typescript was possibly generated by a Mrs Jarrad, working from JGK's hand-written manuscript. A digital version of the typescript was made at Professor Keith Vickerman's request by Lorna Kennedy in 2003. The University also possesses some pages from an earlier typescript annotated in JGK's hand, indicating changes both major and minor made to his original version. We have not included here any text he deleted, but future scholars may wish to examine them.

Correspondence in the University's possession shows that JGK's widow, Lady Isobel Kerr, made considerable efforts to find a publisher for the *Gallery* in 1965, eight years after JGK's death. We have the letters she received, but not those she sent. Her main adviser was Edward Hindle, JGK's successor as Regius Professor at Glasgow. JGK's usual publisher, Macmillan, rejected the work on the grounds of its being too specialised. Lady Kerr turned to Harold MacMillan, recently retired as Prime Minister and back at the family firm, but he politely turned it down too. Hindle suggested some editing and some possible Scottish publishers. Lady Kerr tried for some high-level support. She wondered about Lord Todd, probably Scotland's most famous scientist of the time: Nobel Laureate for his work on the biochemistry of nucleotides. She approached another Nobel Laureate, the physicist George Thomson who, as a boy in Cambridge, had listened to JGK's tales of his South American adventures. The correspondence ends with Hindle and Thomson planning to discuss edits. Lady Kerr died in 1966, which may account for the apparent cessation of efforts to find a publisher for the *Gallery*. From this account, it is clear that the family hoped for the *Gallery* to be published. It seems appropriate, therefore, that this intention has been met in the year of the centenary of the opening of the Zoology building which, since a naming ceremony in 1995, has been called the Graham Kerr building (Fig. 1).

In editing the typescript, we have retained the original text except where there are obvious minor errors. We have also made some punctuation and typeface amendments, e.g. use of italics for species and book names, as is now conventional. To provide context for modern readers, we have added a large number of notes, shown as superscript numbers in the text, and listed in full in the Appendix. JGK mentions a large number of people, mainly scientists and politicians, and we have provided notes on most of them. In a few cases, where the people are really well known, we have not felt the

On 24th May 1995
This building was named in honour of
SIR JOHN GRAHAM KERR M.A., LL.D., F.R.S.
Regius Professor of Natural History and Zoology in the University of Glasgow 1902 - 1935
Member of Parliament for the Scottish Universities 1935 - 1950

Fig. 1. Plaque commemorating the naming of the Zoology Building as the Graham Kerr Building, May 1995.

need for such a note: Charles Darwin and Winston Churchill, for example. The source for most of these notes has been the online resource Wikipedia. The *Gallery* lacks illustrations, and we have felt it appropriate to add some that help illuminate the text. The *Gallery* also lacks some details that readers might wish to know about, particularly information on his family (mentioned only a few times), the books he wrote, and the honours awarded to him. We summarise these below.

Unless credited otherwise, all images are courtesy of the University of Glasgow School of Biodiversity, One Health and Veterinary Medicine.

Family

JGK's first marriage, at Grange Parish Church, Edinburgh, on 7th July 1903 (about a year after his appointment to the Regius Chair at Glasgow) was to Elizabeth Mary Kerr, a cousin and daughter of the Kerrs of Greenhill Terrace, Edinburgh. They had two sons, Adam and Ronald, and a daughter, Isobel. Elizabeth died after a long illness in 1934. JGK then, in 1936, married Isobel Clapperton (nee MacIndoe), widow of his friend Alan Clapperton who had been Secretary to the University Court. JGK's son Adam attended the building naming ceremony in 1995 and unveiled a plaque. He died in 1998. Information on the family came to Maggie Reilly through correspondence with Adam's son Alistair.

Books and archives

In addition to the Gran Chaco book and a short book on reproduction and heredity, both of which are mentioned in the text and notes, JGK wrote:

A Primer of Zoology (1912), Dent, London.

Volume 2 of an intended three volume *Textbook of Embryology*, published by Macmillan & Co. Volume 1, on the Invertebrates, by E.W. MacBride appeared in 1914. JGK's Volume 2, on the Vertebrates, but not mammals, was published in 1919. The mammal volume was to be written by Richard Assheton, but he died before it could be completed, and was never published.

Zoology for Medical Students (1921),

Macmillan & Co., London. For much of his time at the University of Glasgow, medical students were the main focus of his teaching. This volume is based on his lecture course, which was mainly on comparative morphology, but with additional emphasis on parasites of medical importance, and their transmission.

Evolution (1926), Macmillan & Co., London. JGK was a strong proponent of Darwin and evolution. This book provided an up-to-date account of the state of the theory and the evidence for it.

Introduction to Zoology (1926), an eighty-page book in the Benn Sixpenny Library series. As recounted in the *Gallery*, JGK was an enthusiastic participant in popular education.

Hindle's (1958) obituary of JGK provides a bibliography listing 74 published papers. Three bound volumes of his papers are kept in the Zoology Library, Graham Kerr Building. The University of Glasgow Archives department holds a considerable mass of JGK's letters and other papers.

Career awards

In addition to his roles as Regius Professor of Zoology at the University of Glasgow, and MP for the Scottish Universities, both fully described in the *Gallery*, JGK was elected Fellow of the Royal Society of Edinburgh in 1903, Fellow of the Royal Society in 1909, and was knighted in 1939. He was an Honorary Fellow of Christ's College, Cambridge until his death.

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Kerr, J.G. (1950). *A Naturalist in the Gran Chaco*. Cambridge University Press, Cambridge.

A GALLERY OF MEMORIES

John Graham Kerr

Early Years, 1869 – 1892

I was born on 18th September, 1869, and spent my childhood years at Rowley Lodge in the parish of Arkley, Hertfordshire. My parents were both from the Scottish borders – my father a retired official of the Education Department of the old East India Company and, as Principal of the Hoogly College, Calcutta, one of the pioneers in the development of Western education in India. His interests were mainly literature and he had published a number of books[1].

My mother was a Graham, one of a large family among whose descendents were Walter Armstrong – in his day a celebrated art critic, author of monographs on various great painters and latterly keeper of the National Gallery of Ireland – and his three sisters who formed the subject of Millais' well-known picture *Hearts are Trumps*[2]. While I was still a small boy the family moved to Scotland, lived for a time in Edinburgh and then moved to Eskbank, a suburb of Dalkeith, some six miles south of Edinburgh. My mother died in 1874 and thereafter my one surviving sister and I remained under the care of our father and his younger sister, Isabella, who kept house for him.

To my father I owe the foundation of my education. He was a man of high principles, a rigid disciplinarian and a born teacher. When I interrupted his literary work with some question he would get up from his writing table, go to one of his book shelves, pick out the appropriate work of reference and hand it to me without saying a word. By doing so he developed in me the habit of going to original sources to solve my difficulties rather than putting my dependence upon mere question and answer. As I grew older he would give me an occasional hour of more formal teaching: Latin – Cornelius Nepos, Virgil, Caesar, Livy and later Horace – and elementary Geometry and Algebra.

My schools and schoolmasters were varied. Of my schoolmasters, two stand out most vividly in my memory. William Young was the parish schoolmaster of Dalkeith, an excellent example of the old Scottish dominie – not contenting himself with pumping his pupils' heads full of mere information, but instilling into them the things that matter so much more in after life – industry, discipline, manners, tidiness of dress and mind, and ambition to succeed. Untrammelled by a rigid code, he was free to concentrate his efforts upon pupils qualified by their natural ability to profit themselves rather than dissipate his energies upon those destined by nature for the humbler tasks of adult life. It was an interesting experience when, after the lapse of half a century three of his contemporary pupils came together again in Glasgow – one Sheriff Principal of Lanarkshire, one Minister of Glasgow Cathedral and one a Professor in the University.

The other schoolmaster who stands out in my memory is David Munn, mathematics master at the Royal High School, Edinburgh. He had the habit of setting his class problems to do at home. One of my failings was an intense dislike of set tasks: I preferred to wander away along by-ways of my own choosing. The natural result was that when called to produce the solution to the preceding day's problem, I had to be ignominiously silent. I did not like being outshone by the other boys on such occasions and I very soon began to develop a facility for producing an extempore solution in such an emergency. This caught the fancy of Munn – able teacher that he was – who instead of punishing me for neglecting my homework actually encouraged my wrong-doing and eventually invited me to go to his house one evening a week to receive free instruction with his own sons. The result of his treatment was that I became devoted to mathematics and came out easily first in my last year at school. From the Royal High School I proceeded to the University of Edinburgh. I had no cut and dried scheme for my future career. My father had for a time the idea of my entering the Indian Civil Service, but on consulting the Rector of the High School as to the probability of my succeeding in the competitive examination, he was told that 'he could do it perfectly well if he worked seriously for it but that is just what he will not do'. So the idea of the I.C.S. was given up.
My father, while primarily a literary man, had naturally, as one time editor of Bacon's *Novum Organum*, intense interest in the modern developments of science and the result was that my first University studies were in various branches of science: Higher Mathematics, Physics, Geology, Botany and Zoology. It was Geology which gripped my interest most strongly – structural Geology with the dissected volcano of Arthur's Seat and its many other manifestations in the Edinburgh neighbourhood, and palaeontology; many a Saturday I devoted to collecting fossil fishes and the brachiopods of the limestone of Joppa and elsewhere.

Then there came Botany and Zoology. The Botany lectures of these days were held during the summer session in the Royal Botanic Gardens on the north side of Edinburgh at the hour of 8.0 a.m. This involved an early morning walk of 7 or 8 miles; getting up at 4.30 to cook my breakfast, a start at 5 o'clock and arrival at the Gardens soon after 7 a.m. with a good interval for rest and cooling down before the lecture began. Later my father provided a mount so that I arrived in better condition. I attended these elementary lectures on Botany for three consecutive sessions. In the first two of these, 1886 and 1887, the Professor was Alexander Dickson[3], an old-fashioned morphologist who drew fascinating comparisons between the flowering plant with its leaves, and the sertularian zoophyte[4] with its polyps. For his first lecture, the lecture table bore a wonderful display of flowering plants in full bloom. After each day's lecture we had a couple of hours practical work, partly in the laboratory and partly in the gardens. This was looked after by two assistants, Patrick Geddes[5] and J.M. Macfarlane[6], both excellent teachers, in very different ways. I got into the way of evading Pat Geddes as much as possible – he was too apt to branch out into politics and sociology. Macfarlane kept to Botany and was a magnificent teacher, whether in studies of the structure of flowering plants in the laboratory, or in field Botany on our Saturday excursions into the country.

My third session in Botany was marked by great changes due to the advent of a new Professor – Isaac Bayley Balfour[7] – fresh from the Sherardian Chair at Oxford and full of the latest developments of botanical science in Germany, then the great centre of that science, apart from the section dealing with the classification of flowering plants in which England, with the Royal Gardens at Kew under the Hookers[8], remained supreme. The course in Botany under Bayley Balfour widened out greatly, particularly into plant physiology and into the lower forms of plant life such as algae and fungi. The excursions remained as before, for the new professor was a first rate field botanist. After Balfour's first year, both of the old assistants disappeared and were succeeded by younger men of up-to-date training. The Curator of the Gardens also retired, but the younger members of the Gardens staff were greatly stimulated under the vivifying influence of the new professor.

After the morning's work at the Botanic Gardens came the walk up to the Old University buildings, a hurried lunch of a glass of milk and a scone, and then the afternoon at Zoology – lecture and practical class in which we dissected and examined various types of the

animal kingdom. The class of Geology, like that of Botany, included Saturday excursions – both instructive and enjoyable – for Professor James Geikie[9] was not only a field geologist of great distinction but also an excellent raconteur with an ample sense of humour.

The time had arrived when it was necessary for me to decide on a programme, and knowing my interest in natural history, my father advised me to take the first year of the medical course, after which I should be able to decide on my future studies. During these early years at the University, the great majority of those attending the classes of Botany and Zoology were medicals, and as a result of their companionship, I also began to look forward to qualifying in medicine. Accordingly I took up two new subjects, being both occupied by teachers of great distinction: William Turner and William Rutherford[10]. Both in lecture room and dissecting room, the teaching of Turner and his unusually able junior staff was of a very high order. Turner was in these days the chief authority on the comparative anatomy of the placenta, and short courses on this subject and on other aspects of comparative anatomy provided a great treat for a little group of students who were keen enough to attend classes which did not count for any examinations. Rutherford was not, as was Turner, a distinguished researcher, but on the other hand he was a master of the technique of lecturing: a great part of each afternoon he would devote to preparing his lecture for the next day, incidentally covering his blackboard with beautifully coloured and instructive diagrams.

In later years at Cambridge I was made to realise by contrast the importance of lecture technique which in Edinburgh in these days was at a remarkably high level – due I daresay in part to the fact that Scottish University teaching differed from that of the English Universities by being almost entirely by lecture rather than tutorial or practical; and perhaps also in part to the fact that the Professor's emoluments, consisting of his students' fees, were proportional to the number of students attracted to his class. Edinburgh was the one place in my experience where I encountered a teacher that might almost be accused of teaching too well: This was P.G. Tait[11], Professor of Natural Philosophy – a master of Mathematical Physics who gained fame in circles other than academic by providing the simple explanation of why in some of his son Freddie's best golf drives the ball, instead of describing the usual parabola, described a curve concave upwards before dropping vertically to earth. As taught by Tait in my first attendance at his lectures the phenomena of mathematical physics appeared so simple and obvious as to require no special attention and it was only when confronted with the horrors of his examination papers that I was made to realise that I must take his course again and work at it seriously. He did in fact teach too well: he made things too clear. It was a lesson which I never forgot during my own teaching career later on.

Already during my school-days I had become an enthusiastic field naturalist. My earlier holidays were regularly spent at the farm of Castlemains, at the base of the Lammermoors, and close to the Goblin Ha' of Walter Scott's *Marmion*[12], where a brother-in-law bred Border Leicester sheep. In later years I came across one of my first letters to my father: 'Dear Papa, I have caught a trout. Please excuse more as I am going fishing.' A year or two later came the great triumph when, with my little single-barrelled gun, I killed a – surely gigantic – hare in full flight. Fishing, watching birds and other animals, hunting birds' nests, collecting butterflies and beetles, climbing the Lammermoors, exploring the woods and climbing the ruins of Goblin Ha', made each of these holidays a marvellous experience.

Later on came vacations on the west side of Scotland with dredging expeditions to fish up marine creatures from the depths. On one occasion (8th August 1884) while collecting butterflies near Ettrick Bay on the west side of Bute, I had the unforgettable experience of seeing a walrus, surely one of the last occasions of the walrus being seen on the Scottish coast[13]. I felt timid about referring to this observation in later years in view of the fallibility of human memory. However, a few years ago I unearthed an old diary and there I found the incident recorded in such terms as allowed no doubt as to its accuracy: 'August 8th, 1884. In the afternoon we went over to Ettrick Bay. We saw a shoal of porpoises and also a walrus. We got rather a surprise when we saw the head of the latter adorned with large tusks rise in the water quite near us. It soon dived, and we lay quite still expecting it to rise again. This it soon did and we watched it for some time'.

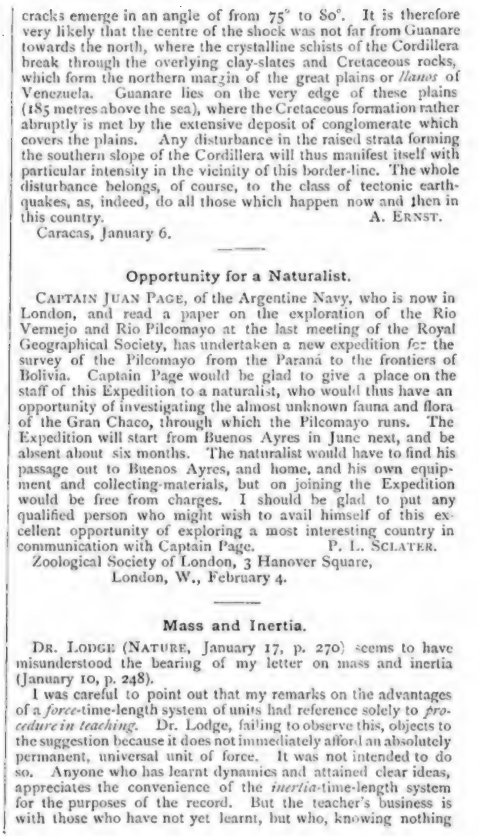
My marine natural history was not limited to the west coast. North easterly gales threw up numbers of squids, sea-mice and other interesting creatures on the sandy beaches of the Firth of Forth between Leith and Joppa, while the rock pools proved to be the home of various rare algae. For a time I collected not only sea-weeds – the algae visible to the naked eye – but also the microscopic diatoms with their beautiful flinty skeletons. Some of the rarest of these I found in the brackish pools near Aberlady. One way and another I acquired a good deal of experience in field natural history apart from my formal courses in zoology in the University. The latter came from the staff of the Natural History Department presided over by Professor J.C. Ewart[14] who was then busy with his remarkable work on the skate, showing how the muscles of the tail, though useless for producing movement, became modified to form an electric organ, useful no doubt as a safeguard against attacks from other fish – for fish are extremely sensitive to electric disturbances.

While attending the various courses in the Natural History Department, I was able to supplement these through the hospitality of Sir John Murray of the Challenger Expedition. Murray had founded the Scottish Marine Station at Granton – on the edge of a large quarry which had been invaded by the sea and converted into a huge aquarium crowded with marine creatures. Murray bade me welcome to the facilities of the marine station and I got much valuable instruction in marine zoology and its laboratory technique from the Director, J.T.

Cunningham[15]. Incidentally, I did not neglect the opportunity of extending my west coast experience of boat sailing for attached to the station was a small Rob Roy canoe in which I made interesting voyages round the islands of the Firth of Forth.

My work in Edinburgh suffered an unexpected break when one day I read in *Nature* (Fig. 2) that the Government of Argentina was arranging an expedition under Captain Juan Page to explore the Rio Pilcomayo and incidentally open navigation to Bolivia from the Paraguay river through the practically unknown region of the Gran Chaco, and that he had at the instance of Dr P.L. Sclater, Secretary of the Zoological Society of London, agreed to allow a properly qualified British naturalist to accompany the expedition[16]. Much of my favourite reading had been on the natural history of South America - Charles Darwin, Waterton, Wallace, Bates[17] - and here seemed to be a marvellous opportunity of penetrating into that realm of romance and incidentally obtaining a valuable addition to my training in Zoology. I was duly appointed naturalist to the Pilcomayo Expedition. The tale has already been told[18], and a few general remarks will suffice here.

The expedition was a failure as regards the main object, but it did give me in my capacity as a naturalist marvellous opportunities for studying the natural history of the Chaco and the customs of a quite unspoilt section of its aboriginal inhabitants - a branch of the nation of Indians known to the Argentines as the Tobas, to the Paraguayans as the Guaycurus, and to the neighbouring races of Indians as the Natokoi. The special interest of the Natokoi of the lower Pilcomayo lay in the fact that their state of constant warfare with their neighbours, whether of the Toba or other races, had kept them isolated and in consequence free from the contaminating influences of other races, whether white or red. The result of this isolation had been that this particular branch of the Natokoi had remained in an extraordinarily primitive stage of communal evolution. They were still in the hunting stage - subsisting entirely on the products of the chase: they had not yet reached the stage of cultivating plants or of keeping domesticated animals: they were still in the wood age, using bows and arrows, and obtaining fire by friction between two pieces of wood. Metal implements were just beginning to make their appearance - an arrow head made from a bit of hoop iron or beaten out fencing wire and capable of being used separately as a knife: or a very occasional axe in place of the heavy wooden paddle-like implement which normally performed the function of an axe in chopping out the soft edible heart of the young palm. In the absence of metal vessels capable of resisting heat, cooking of food was done entirely by broiling or roasting: they had not yet reached the stage of using water for cooking. They had no words for numbers which were expressed by holding up fingers, commencing with the thumb of the left hand, and the normal limit of counting was 5, 6 or in rare cases 7. Time was reckoned in days, moons or years, subject to the numerical limits just mentioned. The time of day was expressed by pointing to the position of the sun -



cracks emerge in an angle of from 75° to 80°. It is therefore very likely that the centre of the shock was not far from Guanare towards the north, where the crystalline schists of the Cordillera break through the overlying clay-slates and Cretaceous rocks, which form the northern margin of the great plains or *llanos* of Venezuela. Guanare lies on the very edge of these plains (185 metres above the sea), where the Cretaceous formation rather abruptly is met by the extensive deposit of conglomerate which covers the plains. Any disturbance in the raised strata forming the southern slope of the Cordillera will thus manifest itself with particular intensity in the vicinity of this border-line. The whole disturbance belongs, of course, to the class of tectonic earthquakes, as, indeed, do all those which happen now and then in this country. A. ERNST.

Caracas, January 6.

Opportunity for a Naturalist.

CAPTAIN JUAN PAGE, of the Argentine Navy, who is now in London, and read a paper on the exploration of the Rio Vermejo and Rio Pilcomayo at the last meeting of the Royal Geographical Society, has undertaken a new expedition for the survey of the Pilcomayo from the Paraná to the frontiers of Bolivia. Captain Page would be glad to give a place on the staff of this Expedition to a naturalist, who would thus have an opportunity of investigating the almost unknown fauna and flora of the Gran Chaco, through which the Pilcomayo runs. The Expedition will start from Buenos Ayres in June next, and be absent about six months. The naturalist would have to find his passage out to Buenos Ayres, and home, and his own equipment and collecting-materials, but on joining the Expedition would be free from charges. I should be glad to put any qualified person who might wish to avail himself of this excellent opportunity of exploring a most interesting country in communication with Captain Page. P. L. SCLATER.

Zoological Society of London, 3 Hanover Square,
London, W., February 4.

Mass and Inertia.

DR. LODGE (NATURE, January 17, p. 270) seems to have misunderstood the bearing of my letter on mass and inertia (January 10, p. 248).

I was careful to point out that my remarks on the advantages of a *force*-time-length system of units had reference solely to *procedure in teaching*. Dr. Lodge, failing to observe this, objects to the suggestion because it does not immediately afford an absolutely permanent, universal unit of force. It was not intended to do so. Anyone who has learnt dynamics and attained clear ideas, appreciates the convenience of the *inertia*-time-length system for the purposes of the record. But the teacher's business is with those who have not yet learnt, but who, knowing nothing

Fig. 2. Letter advertising an "Opportunity for a Naturalist" (*Nature* 39, 341; February 7th 1889).

thus midday was indicated by pointing to the zenith and the behaviour of the hour hand of my watch in acting similarly was attributed to the action of a little spirit which inhabited it. There was as yet no graphic art whether in writing or pictorial. When I first showed my pictures to the Indians, even of animals or trees familiar to them, they failed entirely to recognise a tridimensional object represented on a flat surface though they very soon learned to do so, and were thrilled as I turned over the pages of an illustrated book on natural history. One of the chiefs even got the length of proposing to draw a picture of a man. His portrait of Chinerutaloi - the first picture ever made by a particular race of human beings - is reproduced in my Chaco book[18].

My ambition to be chosen as naturalist to the Pilcomayo expedition had of course nothing to do with these extraordinarily interesting anthropological features of the local Indians. It was due simply to the opportunity it would offer of studying natural history of an unknown region and thereby providing what seemed to me a really essential portion of the education of a professional naturalist. I should have to devote myself to making my

collections and observations of the fauna of the region as extensive as possible. I left Southampton on the 2nd June 1889 in the Lamport and Holt liner *Maskalyne* and reached Buenos Aires on the 29th after a voyage comparatively uneventful but for a violent pampero off Cape Frio on the coast of Brazil. Up to that time I had rather looked forward to enjoying the experience of a real storm at sea, but that feeling perished, never to revive; in that pampero the complete destruction of the smoke room built round the aftermast, and the bending of the bridge stanchions as if they had been made of putty, gave an impressive lesson on the power of waves in a severe storm. The passenger cabin of those days had little comfort, no heating, and the lighting was merely by a single candle hung in gimbals.

We duly arrived at Montevideo on 27th June and there I had one of my first lessons in economics, for near us was anchored a ship laden with Welsh steam coal which was being sold at £1 a ton. The impressive lesson was not that money would pass back into Welsh industry, but rather that once the cargo had been disposed of, there would remain an empty ship ready to be loaded up with food or raw materials for England at greatly reduced freight, an impressive lesson on the balance of exports and imports. From Montevideo we passed onwards over the muddy waters of the Rio de la Plata dotted with numerous floating islands of Camelote (*Pontederia*[19]) which had come down from the warmer regions far to the north. On the morning of the 29th June we anchored in the outer roads of Buenos Aires. The great range of docks and quays of later days were still non-existent and landing was a complicated business - by steam tender, boat and bullock cart.

The four light draught steamships for our expedition - the 'Escuadrilla Pilcomayo y Bermejo' - had been constructed by Messrs Bow, McLachlan & Co. of Paisley and shipped out as separate plates to be put together in Buenos Aires. They were not expected to be ready until the month of December and the delay was most useful in giving me the opportunity of preliminary training of a practical kind in the Natural History of South America - in the Natural History Museum of Buenos Aires presided over by Hermann Burmeister[20], one of the great naturalists of the day; in the swampy region between the city and the river where I was able to wander and watch the bird inhabitants; and above all in a three months sojourn in the heart of the pampas as the guest of Don Benjamin Carbonell, a friend of the Page family. His estancia near the little town of Nueve de Julio was situated in typical pampas country, its slightly undulating surface varied by rush-grown lagoons with a wonderful variety of waterfowl - many species of ducks and grebes, the beautiful black-necked swan and a smaller white swan, herons, including one species with 'dazzle' marking, its dark stripes constituting an extraordinarily effective obliterative colouring among the vertical rushes. The originally treeless pampas had become dotted with plantations round the estancia houses and in these were to be found immigrant forest birds, so that altogether, what with laguna, monte, and open pampas, I was able to get a good foundation training in the ornithology of South America. Mammals too - a couple of species of opossum, and three of armadillo; the coypu - a large water rat miscalled nutria - a name which in correct Spanish belongs to the otter; the biscacha, a large rodent about three times the size of a rabbit which lives in communities or biscacheras, hidden in their burrows during the day but coming out at sundown to feed. When deserted by their regular inhabitants the biscacheras harboured other mammals, a beautiful silver fox, a couple of species of wild cat, a large weasel called huron, and the skunk - which could often be seen taking his leisurely evening stroll, his white tail held aloft as a warning to all to keep their distance.

Of reptiles there were large iguanas and the poisonous snake called Vivora de la Cruz from the cross-shaped markings on its head. It was interesting to see in its habits an indication of the early evolution of the habits of the rattlesnake, for when alarmed and coiled up ready to strike it would vibrate its tail rapidly among the grass stems, making a distinct whirring sound as a warning to the potential enemy.

Of insects, there were the fascinating colonies of gardener ants, their nests low mounds from which radiated clear tracks along which on a warm sunny day could be seen two hurrying streams of ants, those on the homeward stream carrying in their jaws segments cut from the leaves of neighbouring trees. These were carried down into cavities under the ant hill and were there made into beds tended by the gardener individuals, on which were grown threads of fungus which, in response to some unknown treatment, produced tumour-like growths that served as food for the community[21]. Altogether I was able during my three months stay with Don Benjamin to acquire quite considerable qualifications for my duties as naturalist to the Pilcomayo expedition.

It was not until New Year's Day 1890 that our flotilla started on its long journey up the Rivers Parana and Paraguay (Figs. 3 and 4). During our progress northward my pre-Pilcomayo training continued as the fauna became more and more tropical, but it was not confined to matters zoological. Though I was a guest of the expedition and not a paid member of the crew, it was really up to me to do what I could to give a hand in the running of our individual ship, the *Bolivia*. And so it came about that I took my share with the others, a larger share as it happened, for Captain Page very soon discovered that I was knowledgeable about boats and proceeded to give me instruction in the art of river navigation which was his particular speciality. I found it most fascinating, learning to read the surface of the muddy water as expressive of depth, strength and direction of current, snags and other obstacles. I proved an apt pupil and the result was that when we were under way my regular station was at the wheel.

During the early stages the Commander would sit beside me and keep up a continuous commentary upon the water ahead and its indications as to the proper course,

Fig. 3. Map of South America. From Kerr, J.G. (1950). *A Naturalist in the Gran Chaco.* Cambridge University Press, Cambridge.

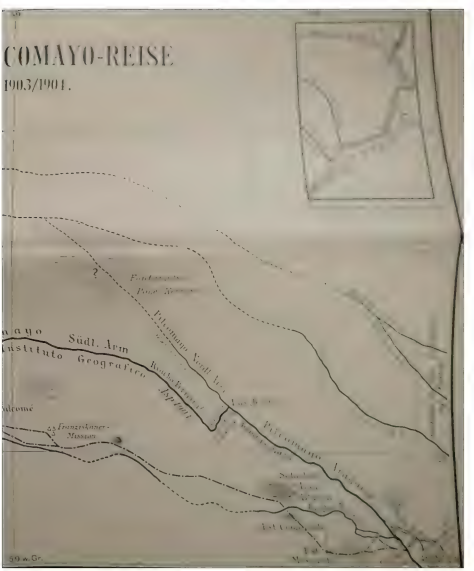


Fig. 4. Detail of map "*Frić Pilcomayo – Reise 1903 1904*" of the Pilcomayo river system, showing the final extent of the Page/Kerr expedition. Image courtesy of University of Glasgow, Archives and Special Collections, John Graham Kerr collection, GB248.

but as time went on he left me more and more to myself in the work of piloting our ship. The climax came when we reached the Rio Bermejo, a tributary of the Paraguay running parallel to the Pilcomayo and at this time in high flood. The Commander decided to turn up into the Bermejo to see how our vessel behaved in its turbulent waters, and the climax of my navigational training came when he entrusted me with the responsibility of navigating the *Bolivia* downstream back to the Paraguay. Throughout the journey which lasted about six and a half hours, in place of the upstream journey of three days, he sat beside me but never uttered a word. At times a swirl of the current would sweep us in towards the bank of hard tosca, contact with which would have meant the end of everything, and I had to edge away from the bank with the greatest care to avoid the stern swinging inwards. At other times a faint ripple would betray the presence of a snag just under the surface. The whole journey required intense concentration and vigilance, and I was a very tired man when at last we shot out into the peaceful waters of the Paraguay.

On 20th January we had reached our up-river base - Barranqueras - on the Chaco bank opposite the city of Corrientes and just below the point of junction of the rivers Paraguay and Parana . A stay at Barranqueras of about a month was occupied in shipping stores on the four vessels and in adjusting their crews. The latter were in the case of the two larger vessels - the *General Paz* and the *Caa Guazu* - ordinary naval crews but in the case of the *Bolivia* they were a mixed lot. Chief Engineer Henderson, an elderly Scot who had sailed with Page in earlier days, second Engineer Cesar, and Italian photographer and Steward, Pool, Carpenter, Higginson, a Scandinavian cook, a negro; ordinary members of the crew, Jack and Smith, negroes, and Kennion an Englishman. Besides these there were on the *Bolivia* Nelson Page, son of the Commander - a midshipman in the Argentine Navy, and myself. At Barranqueras too we were joined by the military contingent - 50 troopers belonging to two regiments of Chaco cavalry with their officers, a particularly tough looking set of men.

On 26th February we started northwards up the river Paraguay and after our six day divergence into the Bermejo and a call at Asuncion, the capital of Paraguay, we reached the Pilcomayo on March 12th. That river turned out to be very different from the grandiose accounts which had inspired our expedition. Navigation was difficult from the beginning along its narrow and tortuous channel but there was also a steady diminution of the volume of its water until at last progress was brought to a full stop. Our Commander now developed the bright idea of constructing a series of dams across the river, each of which would raise the water level sufficiently to allow of further progress. In the event, seven of these dams were constructed and made use of, but by the time the seventh had been constructed at the beginning of June, the flow of water had diminished to a mere trickle and this point, Fort Page, turned out to be the final limit of the *Bolivia*'s voyage up the Pilcomayo. The other vessels of the flotilla had been left behind far down stream.

During the voyage up the Pilcomayo my life fell into a regular routine. While we were under way I took my share of the ordinary work of the crew, and then, when we were brought to a stop by the need to cut the next day's supply of fuel, I went ashore and did my natural history work. Particularly interesting was the late afternoon when I would take a canoe and paddle along up river on the outlook for birds and mammals. A female jaguar would be seen pacing along the bank with her kitten, behaving in her movements just like a large cat. A comical family group of carpinchos[22] - these enormously overgrown cavies - would plunge into the river as I approached. Or one might catch a momentary glimpse of a tapir as it dashed off through the undergrowth. A little creek would open into the river and pushing the canoe through it I would find myself in a wide lagoon, its waters bearing a floating carpet of *Pistia*[23] and *Pontederia*[19], or in places of the great floating leaves of the gigantic water lily *Victoria regia*[24]. And pacing about on this floating carpet would be a troop of jacanas, those beautifully somewhat rail-like birds with enormously elongated toes and claws, and they would suddenly stop their movements and stay for a few seconds motionless with their beautiful lemon-yellow wings stretched vertically upwards.

A fascinating discovery was made when, in the narrowing river, our decks became littered with lichen-covered twigs broken off from overhanging trees as the high upper works of the *Bolivia* brushed up against them: for a large part of the litter turned out not to be lichen-covered twigs but living animals coloured and fashioned into the most perfect semblance of the lichens among which they lived. There existed in fact in the upper branches of the forest trees a whole fauna - lizards, snakes, tree-frogs, scorpions, spiders, praying mantis, locusts, beetles, ants - all showing this marvellous camouflage.

One night during my watch - before we got into Indian territory - a slight sound attracted my attention and looking up I saw a jaguar looking in the moonlight of enormous size, coming in great bounds, attracted by two sheep we had grazing close by. The sheep dashed past me and all I could do was to clap my hands and dash towards the advancing jaguar, which startled it so much that it at once turned and fled - as I myself did equally hurriedly to the safety of the *Bolivia*. Another night, the normal pitch of blackness of the forest was replaced by a ghostly greenish light caused by phosphorescent micro-organisms on the decaying leaves.

The nine months between our arrival at Fort Page in the middle of June and our departure on 28th February 1891 was the really fateful period of our expedition. We were made to realise that we were in Indian territory, for a column of smoke would appear in the distance now in one direction, now in another, but there was no sign of an Indian or even Indian trails. And the fact of their keeping out of sight strengthened our expectation of their not being friendly. The dragging out of the expedition far beyond the time of anticipated arrival at Bolivia and civilization meant that the stores of provisions approached vanishing point and rations had to be reduced to starvation level. A hungry man is an angry man and temper on board was not helped by the realisation that the Commander's mess, comprising himself, his second in Command Zorilla and his son Nelson Page had their own private cache of provisions under the flooring of the Commander's cabin. Mere grumbles developed into really dangerous disaffection and feelings against the Pages, more especially against Nelson, became thoroughly poisoned.

Apart from food troubles there was much illness, and towards the end of June, Zorilla was dispatched down river to expedite the sending of a relief party with provisions. Higginson the carpenter had constructed an excellent canoe and Zorilla took with him as crew Cesar the second engineer and Agustin. With them also departed the doctor of the expedition, Luigi Vignoli, who, weakened by illness and inadequate nourishment, seemed clearly doomed unless he could get away into civilised conditions. He did not get away for he was put ashore and left to his own devices. Late in the afternoon we were astonished by his re-appearance, and abject spectacle, dripping wet, covered with mud, without a coat and with only shreds of stockings on his feet, almost *in extremis*. After a bit he was able to tell us his lamentable story of how the canoe party a few miles down stream from the *Bolivia* had simply dumped him ashore and abandoned him to his fate. We did our best for him but after some five weeks of suffering he died on 8th September and we buried him on the edge of the monte close by.

Meanwhile the Commander too had been going steadily downhill. On 20th July he departed in our one remaining canoe with three men. He died on 8th August, nineteen days after leaving us. The men, fearful of the fate that would be theirs if they arrived at Puerto Pilcomayo and simply reported the death of Captain Page, decided that they must at all costs get his body down to the mouth of the river where it could be examined and death declared to be from natural causes. It was a grim voyage of four nights and three days with the rapidly decomposing body. On arrival the canoe had simply to be buried at once with its contents. It was on 4th October that the news of the Commander's fate reached us, for on that day there arrived a relief expedition of Argentine cavalry who, guided by Jack and Aguirre, two of the men who had accompanied Page, reached the *Bolivia* after a journey of over a month from the Paraguay river. They reported that an earlier expedition had started off to relieve us some months earlier, but nothing had been heard of it and it was feared that it had met with disaster.

Zorilla, they reported, had safely reached the Paraguay but, finding the revolution of 1890 in progress, had departed down river for Buenos Aires, reporting that he had left the remains of the Page expedition dying of scurvy. He also reported that Dr Vignoli had gone mad on the journey down the Pilcomayo, had jumped ashore and had been devoured by a tiger. The ship's company of the *Bolivia* were, not unnaturally, impressed by the extraordinarily well-fed appearance of their rescuers.

The magnificent fat bullocks they brought with them showed every prospect of bringing our own company back to normal, though we found our first meals too rich for enjoyment. The new conditions meant much more than the relief of the food stringencies. What one felt much more at the time was the sudden relief from the continuous strain of constant watchfulness against the danger of Indian attack. It was a delightful contrast now that the responsibility was transferred to the military sentries. On October 5th, Nelson Page departed with a corporal and six men of the relief party to proceed to Buenos Aires for orders. With him also departed two members of our crew - Aguirre and the negro, Jack. Command of the *Bolivia* was entrusted to old Henderson the engineer, until Nelson's return.

On September 18th, my twentieth birthday, came our first sight of the wild Indians. I had gone down river for a short distance to do some washing and returning to the ship, I was hailed by Nelson to come aboard at once as there were Indians about. Two had suddenly appeared a short distance off and had waved their bows and arrows in sign of friendship and had then disappeared apparently to fetch their comrades. Nelson was up on top of the wheelhouse at the Maxim gun and all the others were at their stations. Presently the Indians re-appeared, this time twelve in all. Then one of them, evidently the leader, stepped forward and in the dead silence that ensued, said in Guarami 'We want Pineapple Head'. Our captain made nothing of it but one of our men pointed at me. There was no barber on our little ship and my hair, by nature thick with curls that stood out strong and stiff round my head, evidently reminded the Indian of a pineapple with its bristles. As they still seemed friendly, Nelson and I went ashore to establish contact with them (Fig. 5). Their language was of course quite unknown but a useful beginning was made by their repeating over and over again two words of Spanish *Amigo* and *Tabaco*. One of them who, as we learned later, was the most powerful cacique or chief in the region, had a good knowledge of Guarami, the language of Paraguay, in addition to a smattering of Spanish. He explained that he was a great lover of Cristianos, very unlike the neighbouring cacique upstream who was *muy bravo*.

Fig. 5. The expedition's first meeting with the Natokoi people: JGK is at the middle right back, hatless. From Kerr, J.G. (1950). *A Naturalist in the Gran Chaco.* Cambridge University Press, Cambridge.

The Indians stayed with us three days, in friendly intercourse, retiring at night to the neighbouring monte, and bartered with us some deer skins and ostrich feathers and, better still, food, some thirty guinea pigs and the flesh of three cierbos. When they left, with many protestations of friendship, they promised to return next moon with their brothers. Knowing as we did the treacherous reputation of the Toba Indians and their hatred of the whites, we could not help wondering whether their visit had not really been one of reconnaissance and their return would be to exterminate our small party.

It was about a week after our reinforcement by the relief party that we again became aware of Indians in the vicinity but they did not show themselves openly until just before sundown on October 13th when a number approached the "Bolivia", among whom we recognised some of our visitors of the month before. There was no trouble and from that time onwards we had Indians with us practically continuously during the hours of daylight, watching all our doings, as we did theirs. I busied myself in acquiring a working knowledge of their language and eventually came the great day when Cacique Yordaik announced that some of his men wanted me to join them in a hunting expedition. I duly did so, reflecting that had they had any desire to harm me there would have been endless opportunities during my solitary collecting rambles. That first hunting expedition was in search of the ostrich (*Rhea*) or manik[25]. Our little party, three Indians with their bows and arrows and myself with my rifle, made its way at a swinging pace to the north-westward, to the country of the manik - open grassland dotted with ant hills. We were in single file led by Chimaki who later became my most intimate friend among the Natokoi, I following next behind him, and the two other Indians bringing up the rear. Arrived in the manik country Chimaki and I separated from the others and after a bit Chimaki, peering intently to the left, indicated a manik. To me it was quite invisible. Chimaki became more and more excited and presently started to run round in a circle of about thirty yards radius, excitedly pointing to its centre. At last I became aware that one of the apparent ant hills was surmounted by the slender neck and head of a manik, which as it rose to its full height and started to flee, was brought down by my rifle bullet. It was a male bird and the nest close by contained thirty eggs - the male *Rhea* attending to the incubation of the eggs forsaken by his numerous harem. Preparations were at once made for a meal. Chineraloi produced his fire drill and soon had a fire lighted. The feathers were pulled out and tied together in a bunch. Part of one leg was put to roast. Breaking open the eggs at one end showed to my disappointment well developed chicks but these were fished out, the eggs stood up vertically round the fire to cook and the remains of the yolk duly consumed. After our meal, a short rest, and then I gave the word 'Koluk' - let us go. The unused eggs and the eatable parts of the ostrich were packed in string bags and off we set on our return journey to the camp where we were received with much acclaim.

During the remaining months on the Pilcomayo, my days were normally spent in the company of Indians, wandering about, hunting the various kinds of game, and above all getting to know them more and more intimately. In our earlier days it would happen that every now and then, an Indian would remind me that so many moons ago I killed such and such an animal at a particular spot, and it became borne in upon me that in my supposedly solitary wanderings I had been under the constant surveillance of an invisible Indian spy. I began to realise too that here was the explanation of the attitude of the Indians to myself, so entirely different from their attitude to the other members of the expedition. They had learned that my doings were dominated by my interest in wild animals as were their own. A fellow feeling made us wondrous kind.

The Natokoi were a fine-looking race the men tall and lean, many of them over six feet, their skin sunburning to a dark coppery red, their dark hair cut short a little above shoulder level and often as a fringe over the forehead. All hairs on the face and body were pulled out and absence of eyelashes and eyebrows gave an at first somewhat unpleasant impression. They were particular about their personal appearance and spent much time combing their hair. On ceremonial occasions, as when meeting strangers - friendly or hostile - they painted their faces, a broad band of red urucu across the upper part of the face and narrow black lines along the ridge of the nose and radiating from the mouth. One day early in our companionship, I was summoned by Yordaik to have my face painted and the ceremony was watched with much approbation by the Indians gathered round. I felt that now my inauguration into their communal life was complete. Favourite personal ornaments were white ostrich plumes on the head, and necklaces of rectangular pieces of shell of the freshwater mussel, with the pearly lining outside and showing up well against their dark skins.

The women were also slenderly built, their difference in stature from the men much more pronounced than in European races, their garment like that of the men - a rug worn round the waist and extending down nearly to the knees but of skin instead of woven fabric. They wore necklaces too but composed of overlapping discs about the size of a shirt button, cut from the shells of a large snail *Bulimus*, or, more rarely, of small berries. They did not paint their faces. They were tattooed, the operation performed by an old woman puncturing the skin with a plant spine, and rubbing in charcoal. It was usually done in two instalments, two lines down the ridge of the nose at puberty, and the remainder of the pattern - obliquely intersecting lines covering the cheeks and chin - after the first sexual adventure.

The "tribes" among the Natokoi were not rigid: they were merely groups of individuals clustering round a particular chief or cacique and designated as the 'men of so and so'. The cacique was merely an individual recognised as of outstanding ability, the number of his adherents varying with his reputation. As his power dwindled his followers would drift away. He had no actual command over his men: it was not a case of their obeying orders from him but rather or their realising that he was a wise guide. There had not yet come into existence among the Natokoi the division of power - so unusual among Indian races - between the cacique - concerned with practical affairs - war and the chase, and the 'witch doctor' concerned with the supernatural beings that were held responsible for misfortunes of all kinds.

The upbringing of the Indian boy consisted simply of what we should nowadays call education in citizenship, training to play his part efficiently as a member of the community. The young boy with his toy bow and arrow hunted birds and other small game and in doing so learned far more than merely how to shoot accurately with his arrow; he developed his powers of observation and his powers of rapidly and accurately interpreting the meaning of what he observed. As he became adolescent he associated with the grown-ups, developed his powers further and accumulated a store of knowledge of the local environment: its topography, its plant and animal inhabitants, and the neighbouring tribes, friendly or hostile. The end result was that the average Indian would put an average European to shame both in his powers as an observer and in his condition of constant mental alertness ready for instant reaction to any unexpected emergency.

I had been brought up to think of Red Indians as beings of the utmost solemnity and taciturnity and so it came as a real surprise to realise that so far as the Natokoi were concerned this idea was accurate only as concerned their behaviour in the presence of strangers: in the absence of strangers it was completely different. They were then often quite gay and lightsome. They had a good sense of humour and enjoyed a joke, practical or otherwise.

The Natokoi had no fixed settlements. The encampment at any one spot lasted only as long as it was a profitable centre for hunting and fishing. They had no permanent shelters, no huts or tents. At night the Indian would divest himself of his garment, spreading it on the ground and sleep on it without any covering. In heavy rain he would squat with it over his head. In a storm he would shelter in the lee of a mat or niyik composed of giant rushes and strung up between two bushes. When, towards the end of the expedition I made my way to Paraguay with a small party of Natokoi, it was interesting to notice that when for the first time they saw a house they exclaimed *niyik pok* - big mat.

In their migrations from one camping ground to another they proceeded as always in Indian file, one behind the other, with toes slightly turned in so as to feel the pathway if hidden by darkness or under water: in front, the cacique and older men, then the younger men, each one carrying only his weapons. Behind them the women and children, the women heavily laden. Slung on the back of each by a cord passing over the forehead was a large skin bag containing various stores, on the top of this a roll of dried cierbohide or niyik and several earthenware water vessels with their cord slings. On the

top of all was frequently a little child astride on its mothers neck. Altogether an enormous burden. And in addition she would be steadying her steps with the heavy 'paddle' of cascaranda, often over six feet in length and normally used as an axe or spade.

Whenever possible the route would be along the margin of the monte or forest, into the recesses of which the women would vanish on the threat of attack, while the men remained hidden just within the margin ready to meet the enemy. The new encampment would be sited close by the forest margin and convenient for water supply. A characteristic sight was the departure of the women each evening escorted by one or two men to fetch the supply of drinking water for the night.

The Indians of course do not wash. Their bare skins are kept clean by vital processes just like those of wild animals. The year 1890-91 was, as it happened, unusually dry and the Indians noticed me performing a strange ritual when we came to a pool of water, dipping my hands into it and rubbing them together. Presently, Yordaik felt that he must take over this ritual, so he filled a guinea pig skin with water, took a mouthful from it, squirted the water over my outstretched hands and rubbed them between his own. Though they did not wash, they delighted in bathing during the hot season when their camp happened to be near a deep pool in the river bed. They were magnificent swimmers and used to enjoy the joke of pulling me under water. I had practiced holding my breath for long periods and rather astonished them by disappearing under water and remaining submerged while I made strange sounds by forcing air out between my tightly closed lips.

The normal working day of the Indian commenced before dawn when he started off for his hunting ground - the margin of swamp or *estero* - the haunt of the large deer or cierbo, the edge of the monte - haunt of the beautiful smaller deer, *guazu vira,* and the piglike peccary, the open savannah or palmar - haunt of the *Rhea* and the camp deer[26]. It was fascinating to observe the skill of the Indian in detecting the trail of a wild animal, recognising not only its species but the approximate age of the trail by the extent to which the displaced vegetation had regained its natural position.

What I think impressed me most of all was the tracking down to its nest of a honey-collecting wasp[27]. My Indian companion would point up into the air and exclaim '*Katik'*. I would look in the direction indicated and see nothing or at most some flylike insect. He not only recognised it as *Katik* but - far more astonishing - he was able to judge from some minute peculiarity in its flight whether it was or was not laden with honey. In the latter event he paid no further attention to it but in the former, he knew it was homeward bound to the nest, and he noted the direction of its flight, followed it, keeping a careful look out for any of its companions bound in the same direction and invariably succeeded in finding the nest, a spherical papery structure a foot or so in diameter fixed in the branches of a tree. He would then proceed to light a fire on the windward side of the nest at such a distance that the rising column of smoke swept round the nest. The wasps very soon emerged and flew away to a neighbouring tree and when the nest was completely deserted he climbed up, detached it from its supports and brought it down. Breaking it open we had a great feed upon the honey, but a special delicacy was the large and plump grub of a beetle which was an unusual guest in the wasps' nest. It was cool and juicy and went off in one's mouth with a plop like a ripe gooseberry.

During my wanderings with the Indians I had the opportunity of learning more of their social customs. The correct time for a visiting party to arrive was just before sundown. They approach in single file, the men in front. They are invited to sit down. The do so in a circle, the visiting cacique beside his host. For a long time not a word is spoken. The visitors attend to their toilet, comb their hair, arrange their headdress, paint their faces and when all is well conversation begins, at first purely formal. 'We have come from the West'. 'You have come from the West'. 'There is much water'. 'There is much water'. 'We fought the men of so and so'.'You fought the men of so and so'. And so it goes on, the host politely repeating verbatim each announcement of his guest.

One time I proceeded with Yordaik to pay a call on Yokoidyi and his men. On our arrival at their camp they spread skins on the ground for me to sit upon. The two caciques squatted down besides me, and the tribesmen in a circle. Then an immense gourd holding at least a gallon and a half of luktaga - a kind of mead made from honey or from the chewed-up fruits of a Chaco locust bean - was placed on the ground in front of Yoikoidyi who handed out the drink in a small gourd, first to me and then to the others, going round the circle clockwise - which suggests there may be something very ancient and ancestral in our own way of passing round wine at table. In spite of the quantity of luktaga in the large gourd it had to be replenished so as to give each man about a pint. That was sufficient to make the Indians very talkative, denouncing in particular their enemies and mine, the Nimka, and their intention of utterly annihilating them.

When a party of strangers visiting an Indian encampment includes women, they come in separately one by one after the men, their hostesses running out to meet them and relieve them of their burdens. They then disappear from view, the women remaining apart from the men on such ceremonial occasions, as indeed during the greater part of their ordinary lives except when the tribe is on the move. Polygamy was the rule among the Natokoi - young wives being added one after the other till there might be as many as four or five. They had a high standard of fidelity to their husbands and divergence from this met with severe corporal punishment administered by the other women.

While I kept happy by the continuous interest of my life, others were less fortunate. Service in the Chaco regiments of the Argentine army was in many cases a punishment for previous crime and was subject to harsh

and rigid discipline. The prolonged period of comparative idleness encouraged the always present spirit of disaffection and on 19th January the unpleasant discovery was made of a plot among the troopers to get rid of the rest of us and secure freedom by flight into non-Argentine territory. It was essential to act at once and give the alarm to the Argentine authorities. This could be done only by sending a personal messenger and it was realised that I, from my experience with the Indians, was the most likely person to succeed in getting through the country of hostile Mushcui and reach the military post at Puerto Pilcomayo. When I sounded my friend Chimakyi about coming with me he agreed enthusiastically and on the morning of the 22nd we departed, ostensibly on a hunting expedition. A few leagues downstream we were joined by six other Indians, every one of whom I would have chosen without hesitation as being especially competent in any trouble we might have. The chief Chimakyi and another Indian even accompanied me to the hotel in Asuncion and slept the night outside my bedroom door. The tale of that journey has already been told in my *Naturalist in the Gran Chaco*[18] and all I need say here is that after six days' journey through very difficult country, we duly reached Paraguay.

Six days in Asuncion were busily occupied in the purchase of supplies, including bullocks to take back to the *Bolivia*. One day I took a boat down to Puerto Pilcomayo, the Argentine military post at the mouth of the Pilcomayo, and reported on the trouble amongst the military contingent at the *Bolivia*. I was given a fresh lot of cavalry to form an escort and duly arrived back at the *Bolivia* to find that, as I had anticipated, the disaffected troops of our original relief party had been on their best behaviour after I had managed to slip away.

The Government was so pleased with my services and also by being the first white man to have established friendly relations with the Indians that they offered me a large tract of land to continue work amongst them. My friends among the Indians had an alternative plan that I should become their chieftain or leader. A wigwam had been prepared for me and two of their young women promised to be my companions. However, in Paraguay I had bad news of my father's failing health and felt unable to accept this offer, and remained with the *Bolivia* only long enough to get my collections safely packed up. On March 15th I started on my homeward journey, taking with me as much as could be transported on five mules and leaving the rest on board the *Bolivia* with instructions as to its eventual transport to Edinburgh[28].

On my return from the Gran Chaco I settled down to resume my medical studies in Edinburgh. In the autumn took place the death of my father, and during the winter session I resumed my university studies and attended classes in Pathology and Surgery. But my attention wandered. I was elected President of the newly formed Darwinian Society, one of the series of short-lived students' societies devoted to Natural History. Then there was the task of working through my collections of bird skins from the Pilcomayo, the one fragment of my zoological collections which I had been able to bring home. As the session advanced, I became more and more decided to quit finally the curriculum in medicine and devote myself to training as a professional zoologist.

In the Autumn of 1892 there came to the British Association meeting in Edinburgh, Edwin Ray Lankester[29], the leading naturalist of the day. He stayed at Inverleith House with Professor Bayley Balfour[7] who, ever interested in my future career, arranged tête-à-tête breakfast with Lankester at which I could get his advice. That advice was quite definite: first, that I should complete my medical curriculum and thereby become a member of what he described as 'the strongest trades-union in the country', and thereafter come to him in Oxford for my special training as a professional zoologist. I was duly grateful to Lankester for his advice, though the sequence of subsequent events was not in accordance with it.

On the Saturday of the meeting I took a little party for a walk across the Pentland Hills - P.L. Sclater, his son W.L. Sclater, and young Charles Dalrymple of Newhailes. Philip Lutley Sclater[30], Secretary of the Zoological Society of London, whose autocratic ways had earned for him the nickname of 'Emperor Philip' and who had been more responsible than any other single individual for raising the Society with its Zoological Gardens from a comparatively obscure position, was one of the leading figures among the British scientists of his day. He had been responsible for my being chosen as naturalist to the Pilcomayo Expedition and he continued in subsequent years to be my ever-watchful adviser and guide. He and Isaac Bayley Balfour earned from me a debt of gratitude which could never be repaid.

Half-way across the Pentlands, Sclater called a halt and said: 'Now we shall decide the fate of Pilcomayo', his sobriquet for myself. His son Willie - also a professional zoologist - although trained at Oxford had had some experience of teaching at Cambridge and his advice was that I should go to Cambridge and to Christ's - the college of Charles Darwin - where I should have the advantage of having Arthur Shipley[31] as my tutor. This wise advice decided the matter in my mind. I wrote at once to the Master of Christ's and in view of my unusual circumstances he agreed to my immediate admission to the college.

My objective being an Honours degree in Zoology, the first hurdle to be surmounted was the Previous Examinations or 'Little Go' which would involve my return to subjects neglected since my schooldays. The Little Go at that time was divided into two parts: I, Classical - including one of the gospels in the original Greek - and II, Mathematical, with a paper on Paley's Evidences[32]. As Part I would clearly require a good deal of brushing up of my very inadequate classical training, I decided to concentrate for the moment on Part II and rid of it before the beginning of the October term. I accordingly proceeded to Cambridge in September,

1892, and was up in college for the period of the examination and duly got rid of Part II. Preparation for Part I turned out to be a great nuisance as it involved attendance at college lectures on classics when I should have been able to devote my whole time to the University course in elementary biology and it eventually required a threat by the college authorities to deprive me of a provisionally awarded scholarship unless I passed the examination at the very next opportunity. When the pass list appeared I found my name included in the Third Class instead of the minimal necessary Fourth.

Cambridge, 1892 – 1902

My previous experience in Edinburgh and South America made me appreciate to the full my life as an undergraduate at Cambridge. My new comrades, coming for the most part from the great public schools of England, differed considerably from my fellow students in Edinburgh. However, we got on well together. I liked them and they appeared to enjoy my strange tales of South America. I was elected to the two chief college clubs, both of which unfortunately met on Saturday evenings, so I had to make the choice between them. Of the two, I chose the Shakespeare Society - the activities of whose eleven undergraduate members consisted of the reading of Shakespeare's plays, rather than the Apostles, the activities of whose members lay along more lively lines.

Games as always had for me little appeal (apart from rowing) but this soon turned out to be impossible at Cambridge owing to the afternoon hours being demanded for work in the laboratories. So athletics of any kind took no place in my undergraduate life at Cambridge. Of the Christ's undergraduates of my time, the one who became a conspicuous world figure later on was Jan C. Smuts[33]. The Christ's community at the time naturally failed entirely to realize that they had among them one destined to become a great figure in world history. Smuts showed no interest in undergraduate communal activities and concentrated entirely on his work for the Law Tripos in which he duly got his First Class in both Parts (1894).

Apart from undergraduates, I found myself welcomed in Cambridge by many of the senior people. My old Edinburgh teacher, Isaac Bayley Balfour[7], who had previously been Sherardian Professor at Oxford, was particularly kind in giving me introductions to many of his personal friends. Then one week-end during my first term, there came over from Oxford E.B. Tylor[34], author of *Primitive Culture*, and the great pioneer of modern ethnographical science. He had heard of the Pilcomayo expedition and came at once to question me about my experiences among the Chaco Indians. There was to be a gathering on the Sunday evening in Dr Henry Jackson's[35] rooms in Trinity where Tylor was staying and he kindly insisted on my coming to it. The hardly breathable smoke-laden atmosphere of the crowded rooms nearly proved too much for me and Tylor had to take me out and walk me up and down in the fresh air for a bit before my faculties were fully restored. However, it was a great experience to meet and converse with many of those already well known to me by name, and destined later on to become intimate personal friends. The particular occasion of that evening was a meeting of the *ad eundem* club, composed of Oxford and Cambridge dons who dined together once a term in one or other university alternately. Following subsequent Cambridge meetings of the club, Henry Jackson got into the way of asking me to Sunday breakfast where the little company was always composed of persons specially interested in anthropology - including James G. Frazer[36] - to become famous later through *The Golden Bough*.

Another meeting place was Magdalene College on Sunday evenings where Alfred Newton[37], Professor of Zoology, was at home to Cambridge naturalists whether senior or junior. It happened one evening that two friends standing by me, Evans[38], the author of *Birds* in the Cambridge Natural History, and Somerville[39] - in his day Professor of Agriculture, first at Cambridge and later at Oxford - were reminiscing about one of Alexander Dickson's botanical excursions to Gordon Moss in Berwickshire and incidentally mentioned one the students having collected three live adders. I was able to confess that I was that student.

In October 1893 I was elected a member of the Cambridge University Natural Science Club which met regularly on Saturday evenings during term time and after refreshment in the form of coffee and "whales" (otherwise sardines) on toast proceeded to hear a paper by a member on some scientific subject followed by discussion. The Club was somewhat select as to its undergraduate membership and limited to twelve. Amongst these there were included from time to time a large proportion of those who achieved later a distinguished position in the world of science. Among my own contemporaries for example were such botanists as Seward, Burkhill, Keeble, Willis, Tansley and V.H. Blackman[40,41].

Although not a physicist, it fell to my lot to propose Rutherford[42] for membership as I had got to know him intimately at the house of J.J. Thomson[43]. I was a little anxious about his candidature, for he had of course not yet made himself famous and he was a new type of candidate - aiming not at the Cambridge Honours degree by way of the Natural Science Tripos, but at the just inaugurated research degree. However, all was well and he was duly elected on May 2nd 1896. He reminded me in after years that his first meeting happened to be in my rooms at the height of a bitter war over the proposed expulsion of a member who had failed to do his duty in the way of communicating a paper and regrettably was able to quote verbatim a sentence in which I endeavoured to score off a member on the opposite side.

Another privilege that came my way as an undergraduate was my election as an Associate of the Ray Club. This club, though founded (1837) in honour of the great naturalist John Ray[44], was not restricted in its membership to naturalists in the ordinary sense. Its

membership of twelve included during my associateship Sir George Stokes[45] and Professor J.J. Thomson, physicist. The object of the club was stated to be 'the cultivation of Natural Sciences by means of friendly intercourse and mutual instruction'. There were twelve meetings in the year, held in members' rooms, and the host of the evening was enjoined that it was expedient 'to bring some subject of scientific interest under the consideration of the members'. Members of the University *in statu pupillari* were eligible for election as Associates - limited to six in number. Associates had the privilege - greatly valued - of attending all the meetings of the club. The only other Cambridge Societies I joined during my undergraduate period were the Union Society which was useful as an ordinary club and the University Cruising Club which I joined in 1895 soon after its foundation.

Throughout my Cambridge days, however, I kept in touch with the Zoological Society of London, and in 1928, I was elected a member of the Zoological Club which in those days dined at the Café Royal before the scientific meeting of the Society at 3 Hanover Square. These dinners left many interesting memories - of W.H. Hudson[46] in the days before he became a famous author, of Harry Johnston[47] and his bandolier from the Semliki forest of striped skin supposed to be that of a new species of zebra (*Equus johnstoni*) but which turned out to be an entirely new type of animal, the okapi.

A student of science coming to Cambridge from the University of Edinburgh could not fail to be struck by the fundamental difference in the technique of teaching in the two schools. In Edinburgh the lecture was all important, in Cambridge it ranked as of comparatively little importance as compared with practical and tutorial instruction. In Cambridge I encountered no lecturer comparable with Tait or Rutherford. Michael Foster[48] delivered his lectures on Physiology in a dull monotonous tone of voice, rhythmically shifting a row of coloured chalks on the palm of his left hand. He was clear enough and one did feel as the lecture proceeded that one was absorbing something of the subject, until there came his favourite concluding sentence: 'However, the time is not yet ripe to dogmatise' - an effective means of quenching the dawning interest of the elementary student. It was only after passing beyond the elementary phase that one realised that this type of lecture with its monotony, its hesitancy, its uncertainty, its freedom from dogmatic assertion, though less captivating at the time, provided a far sounder foundation for a scientific career.

The Cambridge school of Zoology in those days was outstanding among the zoological schools of the world, its standing being comparable with that the of the Cavendish Laboratory in the realm of Physics. Its personnel included Alfred Newton, Professor, Adam Sedgwick, Reader in Animal Morphology, Bateson, Gadow, Harmer, Hickson - all of the Fellows of the Royal Society, each one of them of outstanding reputation as a researcher, a teacher or a personality[49,50].

The rise of the Cambridge school to this position had been an aftermath of the work of Charles Darwin in forcing upon the attention of the world the fact of evolution and in adding important arguments that a main causal factor in bringing about evolutionary progress was the natural selection of favourable variations. The intense interest aroused by Darwin's work stimulated scientific enquiry along three main lines to test its validity: First, the actual evidence of evolution; second, the facts of variation; third, the struggle for existence among wild creatures living under natural conditions, and the weight to be attached to it as bringing about the 'survival of the fittest'. Of these three lines of enquiry, the first two were specially adapted to a university with its museum and laboratory equipment, and it was accordingly along these lines that the Cambridge school of Zoology had developed. It followed that the general spirit of the Cambridge school was morphological - the study of the structure of animals - their comparative anatomy and embryology - for therein lay the actual facts demonstrating the evolutionary progress of the various types of animal.

In the decades succeeding the publication of *The Origin of Species* there had accordingly emanated from Cambridge an immense amount of research in animal morphology. Such importance had been assumed by this section of zoological science that in 1882 a special Chair in Animal Morphology was founded, supplementary to the Chair of Zoology but provided with full laboratory equipment. The first and only occupant of the Chair was Francis Maitland Balfour[51], brother of Arthur James Balfour, the statesman, and himself one of the chief pioneers in the subject of vertebrate embryology. After the premature death of Balfour the teaching post in vertebrate morphology was continued as a Readership occupied by Adam Sedgwick. The Tripos courses in elementary Zoology were given by Sedgwick, the Professor confining himself to a few lectures upon Evolution given at the unpleasant hour of one o'clock to a handful of students. A special feature of Sedgwick's course was that several meetings were devoted to the practical study of the developmental stages of the bird, each student opening for himself the hen's egg at various stages and examining the contained embryo. Nothing I had encountered in Edinburgh gripped the interest of students in the way that this did.

The Natural Sciences Tripos consisted of written and practical examination on each of the main subdivisions of Natural Science. It consisted of two parts of which Part I was compulsory. The fate of the candidate was decided by the aggregate of his marks and it was customary to take three or four individual subjects. It had to be taken not later than the end of the third year. Part II, which had to be taken before the end of the fourth year, was all-important to anyone looking forward to a professional career in science and I decided to take my Part I at the end of my second year so as to leave two years free to prepare for Part II. With an eye to the aggregate marks determining the result of Part I, I decided to offer four subjects - Zoology, Physiology, Geology, Botany. But I soon deserted Geology. The

local geology of the Cambridge countryside seemed to me intolerably dull after my experience of Edinburgh with its wonderful variety of structure, its dissected volcanoes and its fascinating fossil fish.

An important factor in my zoological education came from an unexpected incursion into original research during the time that I was working for my Tripos. Sedgwick had received from a missionary a number of specimens of the pearly nautilus[52]. The empty shells were familiar, being constantly thrown up on the shores of the Indian Ocean, but the complete animal was extremely rare and the investigation of the few known specimens had shown it to be of great scientific interest and importance. Sedgwick handed over his specimens to me to see what I could make of them. They had been packed in sawdust moistened with rum but in spite of this crude method of preservation their condition was good enough for ordinary dissection.

They turned out to be peculiarly favourable material for a beginner's first research, for not only was the morphology of *Nautilus* of great importance owing to its being a modern survivor of those ancient molluscs that were the evolutionary ancestors of our modern cuttlefish, but also owing to the very small bulk of the previous literature on the subject the tiresome task of working through that literature was reduced to a minimum[53]. I found the work extraordinarily interesting, and - in addition to providing important new knowledge of the morphology of *Nautilus* and the cuttlefish group of molluscs - it inspired my determination to concentrate my future research so far as possible upon those archaic, relatively primitive, types of animal life which have come down to the present day comparatively unchanged since the early days of geological history.

The small group of students proceeding to Part II of the Tripos attended special courses dealing with particular groups of animals which were given by Harmer, Hickson, Shipley and Gadow. These courses were really admirable. In after life I often wondered whether anywhere in the world the student of Zoology was given training in all the main groups of the animal kingdom in any way comparable with that given to Cambridge Part II students of those days. A great character among our Part II teachers was Dr Hans Gadow who on three mornings a week delivered with great enthusiasm a lecture on the morphology of vertebrates, punctuated occasionally by the sound of bursting buttons from his rather tight-fitting garments. He had been an officer of the Prussian Guard and his manners were not always of the best. The feelings of J.J. Lister were ruffled one day as he sat in the Balfour library busily performing his duties as honorary librarian when he heard himself referred to (to some German visitors) as that slug (Nacktschnecke). However, Gadow taught us admirably and on an occasional Saturday would take us up to London for a few hours at the Zoo or the Natural History Museum.

He lived in a little house in Chesterton Road and there he kept a number of unusual pets. After my return from the Gran Chaco in 1897 he appealed to me to obtain a living escuerso (*Ceratophrys*)[54], an Argentine toad which commonly eats frogs but occasionally devours chickens. So I appealed to a friend on the Pampa and in due course heard from him that he had obtained a couple of live escuersos and had entrusted them to the purser of one of the mail steamships to bring over to England. Eventually the packet reached me in Cambridge by parcel post, so I took it to Chesterton Road before opening it. When it was opened there was revealed in its interior not two but one - very replete-looking - escuerso which was christened Juanita and lived happily for some years. Still another South American pet was Maria - one of the huge toads called by the misleading name *Bufo marinus*[55]. One long vacation Gadow went away for a holiday and deposited her for safety along in the animal house belonging to the Department of Physiology. Unfortunately, it happened one day that a student of Physiology about to prepare a nerve-muscle preparation proceeded down to the animal house to obtain a suitable frog for the purpose. To his joy her perceived there a magnificent specimen of unparalleled dimensions, and he was in the midst of his vivisection when there came along one of the lecturers of Physiology who shrieked out, 'Why! good God! that's Maria'. The student wisely fled away home but he did not escape communications fully expressive of Dr Gadow's sentiments.

Our two chief teachers on invertebrates were Sidney Harmer (later Sir Sidney and Director of the British Museum (Nat. Hist.))[56] and Arthur Shipley (later Sir Arthur and Master of Christ's College). Each was officially Lecturer on the Advanced Morphology of Invertebrates but each did much additional work for the University. Harmer was Keeper of the University Museum of Zoology and was in many ways an ideal Keeper. To him the contents of the museum were sacred: everything was labelled and catalogued with the greatest care: and every precaution taken to see that conditions attaching to any particular gift were duly fulfilled. Shipley, in addition to many other duties, acted as Tutor in Natural Science in Christ's College and I found him an ideal tutor, ever ready to help when called upon but never fussy and interfering.

My undergraduate career came to an end with the May term 1896 when I was lucky enough to obtain my 'First' in Part II (Zoology). I was now ready to start a programme of research which had been gradually forming in my mind. The bit of zoological science which had specially excited my interest was the evolutionary history of vertebrate animals and particularly of the various organs constituting their bodies. The facts out of which this history was built up were the facts of structure of the vertebrate body - in the adult and during the developmental stages - in other words, the comparative anatomy and comparative embryology of vertebrates. But during my student period I had been not merely gripped by the interest of these departments of zoological science. I had also been deeply impressed by their deficiencies. Our knowledge of comparative anatomy was practically confined to those forms of animal life still existing at the present day. Geology was

unable to disclose any information except regarding skeletons composed of mineral material. All the important living tissues of the animal were composed of organic material perishable in their nature and incapable of being preserved in fossils. Palaeontology, in fact, so far as concerned vertebrates, was merely palaeosteology.

Working at Cambridge, so intimately linked with the modern evolutionary philosophy of Charles Darwin, and where an important part of the foundations of vertebrate embryology had been laid by Francis Balfour, it was not surprising that I became inspired with the idea of devoting myself to the study of evolutionary embryology. It had, however, become borne in upon me during my reading for the Tripos that the existing science of vertebrate embryology suffered from a fundamental defect inasmuch as it was based upon facts gathered from readily available types of vertebrates such as the fowl and rabbit, and to a lesser extent frog and elasmobranch fishes such as skates and rays. Such old-fashioned vertebrates as *Polypterus, Lepidosiren* and *Protopterus*[57], types which had admittedly come down comparatively unchanged from remote geological times, were entirely unknown so far as concerned the early stages of their development. It seemed to me that the general principles of vertebrate morphology could not be regarded as firmly established so long as they ignored the embryology of these archaic types which still survived in remote parts of the world.

And so it was that I decided to devote my research activities towards dispelling this ignorance and determining to what extent the newly acquired knowledge confirmed or modified the current ideas of vertebrate morphology. Of the three archaic types mentioned one, namely *Lepidosiren,* was known as an inhabitant of the Amazon region but a German collector had recently obtained specimens from Chaco Indians on the banks of the Paraguay river. In view of my familiarity with the Gran Chaco and its somewhat difficult conditions I decided to give *Lepidosiren* precedence over the African *Polypterus* and *Protopterus* and make a special expedition to the Gran Chaco to tackle the *Lepidosiren* problem as soon as I got rid of the Tripos.

Having got together my necessary complicated equipment, I sailed from Southampton on August 7th 1896 accompanied by my friend John S. Budgett[58] (Fig. 6) of Trinity College. The full tale of that expedition and its adventures while worrying out the habits and life-history of *Lepidosiren* and transporting the priceless material to Cambridge has already been told in detail in *A Naturalist in the Gran Chaco* so I will now content myself with a brief summary. The site of my *Lepidosiren* work was again in the Gran Chaco, but among a different nation of Indians known as the Lenguas, a name surviving from former days when, in addition to their ear discs, they wore a similar disc in the lower lip, causing it to hang down like a tongue (Spanish *lengua*). Among the Natokoi and other Indian races of the Chaco they were known as the Mushcui and I had

Fig. 6. John Samuel Budgett. From Kerr, J.G. (1907). *The Work of John Samuel Budgett*. Cambridge University Press, Cambridge.

memories - regarding which I had to be discreetly silent - of the active hostility between them and my friends of the Pilcomayo.

Although in their general features typical red men, the Lenguas showed differences in detail from the Natokoi of the Pilcomayo. When in 'full dress' the face was painted red with urucu but without the superimposed black lines of the Natokoi: and the women were without the tattooing customary among Natokoi. They had advanced from the stage of having merely the cacique at the head of the tribe. There was now a 'witch-doctor' - outstanding in his knowledge of the environment - material and spiritual, of the animals and plants of the region, and of the evil spirits responsible for misfortunes of all kinds. There was a good deal of infanticide. A child born after the death of the father was killed. An infant whose mother died was buried alive with her. At other times an infant's death would be decided by the witch-doctor who killed it by a blow on the back of the neck. Personal names among the Lenguas were nicknames descriptive of some personal peculiarity - usually unfavourable and - no doubt in view of this - a man's name was never mentioned in his hearing. My own name Oyankintimgyethlnaapkatik – 'Pineapple head' - I learned indirectly through a missionary friend.

On this expedition my original plan was to make our way to the country of the Natokoi and there settle down to search the swamps for *Lepidosiren*. However, on our way up the Parana I foregathered with a fellow Scot named Graham who told me he was going as a recruit to

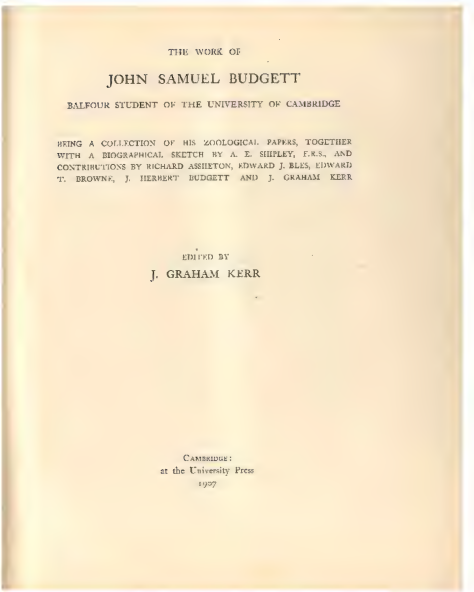
the South American Mission's station in the Chaco under W.B. Grubb. I at once pricked up my ears at hearing this name for I remembered that in a note published by a collector for the Hamburg museum and chronicling having got specimens of *Lepidosiren* from Indians on the Paraguay river he had mentioned his indebtedness to 'mein Freund Grubb'. So I at once decided that our first objective should be to interview Mr Grubb. We found the base of the Grubb mission on the Chaco bank of the Paraguay River opposite the town of Conception, some two hundred miles north of the Pilcomayo. Grubb was himself absent on leave in England but his colleague, Mr John Hay, told me that the main mission station was located at Waikthlatingmayalwa in the interior of the Chaco among a set of Indians known as the Paisiaptó or Black food people, owing to a staple article in their diet being a dark coloured fish called loalach and obviously *Lepidosiren*. I was able to arrange with the missionaries to provide us with board and lodging at Waikthlatingmayalwa and transport thither by bullock cart with our impediments. A week's journey through country very much like that of the Pilcomayo region brought us to Waikthlatingmayalwa where we were welcomed by the two resident missionaries, Andrew Pride and R.J. Hunt. A party of Indians close by were cooking their supper of *Lepidosiren* and one of them brought me some on a plate so that I had the distinction of being the first zoologist to eat this sacred creature.

The carts with our equipment arrived a week later - Budgett and I had ridden on ahead with an Indian guide - and we at once proceeded to rig up a laboratory under the veranda of the mission station. There followed four months intensive work - wading about in the neighbouring swamp, studying the habits of *Lepidosiren*, discovering burrows at the bottom of the swamp in which the eggs were laid, collecting the eggs and keeping them in aquaria so as to secure a complete series of all stages in the life-history, preserving the eggs and larvae by different methods, and finally storing them in hundreds of glass tubes.

While I was busy with *Lepidosiren,* Budgett proceeded with his work for Part II of the Tripos, supplementing his reading by dissection and other practical work on the varied types of animal obtainable in the neighbourhood. He also concentrated on a special study of the numerous species of frogs and toads and of the curious modifications of their spawning habitats which enable them to cope with climatic difficulties caused by prolonged drought with only very short intervening periods with water available for the tadpole stage. This formed the first bits of research in Budgett's tragic career, ending in his death from black-water fever when, after four expeditions to tropical Africa, he had at last succeeded in his quest for the developmental stages of *Polypterus*. The rainy season - the onset of which determined the spawning of *Lepidosiren* - commencing most opportunely just at the time of our arrival at Waikthlatingmayalwa - turned out to be a particularly severe one, the waters of the swamp spreading round the mission station which came to be situated upon an island of ever-diminishing extent. About the middle of February we decided to make an attempt to transport the developmental material of *Lepidosiren* to Paraguay. We started on 18th February - on foot, for the horses had all died of the epidemic disease *Mal de Caderas*[59] - the precious *Lepidosiren* material in a bullock cart - and after a week's very laborious travelling over country, most of which was still under a few inches of water and covered with the matted rank growth of the rainy season - we reached the River Paraguay.

We stored our material in Villa Concepción and then commenced a delightful month's holiday in Paraguay along with Mr Hunt. Our base was the little town of Villa Rica where we found the great topic of conversation was the collapse of the Socialistic experiment of 'New Australia'[60] which had started under such favourable auspices with a grant from the Government of nearly 600 square miles of some of the finest land in the country. The human material too was of the most suitable kind, most of the colonists being countrymen from the back blocks of Australia with experience of the kind of activities required to make the Paraguayan experiment a success. It was pathetic to hear at first hand from individual colonists their account of the collapse. 'Lane (the Leader) did the thinking: the colonists did the work'. 'Everyone wanted to be schoolmaster, none to be scavenger'. The one activity that really prospered was the holding of meetings with interminable debates.

From Villa Rica we made an interesting little expedition to the small town of Caa Guazú, a couple of days' journey to the northward, involving a seven leagues' ride through luxuriant virgin forest with hardly any signs of animal life except when the track crossed a little rivulet running through a sunny open glade. Here there were myriads of butterflies, endless in their variety. In the memoir of Budgett published after his death[61] (Fig. 7) there is quoted his account of the show of butterflies in one of these valleys. When he dismounted to let his horse drink 'the air seemed filled with the flapping of flimsy wings'.'Twenty-five were perched upon me at one moment, six upon my gun-barrel, my horse too was pretty well covered while a great *Morpho*[62] had alighted on his forelock'. Towards the end of our month in Paraguay, I became anxious to get back to Waikthlatingmayalwa as the dry season would now be well advanced and the conditions suitable for studying the dry season habits of *Lepidosiren*, so I pushed on ahead of Budgett and Hunt. My journey was unfortunately interrupted by a severe attack of malaria and it was not until 25th April that I was able to make a fresh start from Concepción accompanied by Budgett who had overtaken me, and Grubb who had returned from his leave in England. With fresh horses and dry country, the journey from the Paraguay River to Waikthlatingmayalwa took us only three days. Great expanses of swamp, where there had been five feet of water, had now only a few inches or were completely dry, and the lungfish had burrowed down into the mud in preparation for their wait until the advent of the next



THE WORK OF

JOHN SAMUEL BUDGETT

BALFOUR STUDENT OF THE UNIVERSITY OF CAMBRIDGE

BEING A COLLECTION OF HIS ZOOLOGICAL PAPERS, TOGETHER WITH A BIOGRAPHICAL SKETCH BY A. E. SHIPLEY, F.R.S., AND CONTRIBUTIONS BY RICHARD ASSHETON, EDWARD J. BLES, EDWARD T. BROWNE, J. HERBERT BUDGETT AND J. GRAHAM KERR

EDITED BY

J. GRAHAM KERR

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Fig. 7. Cover of Budgett memorial volume. From Kerr, J.G. (1907). *The Work of John Samuel Budgett.* Cambridge University Press, Cambridge.

rainy season, breathing by a passage kept open in the gradually drying mud and subsisting on the fat stored up in their bodies during their period of activity.

We passed four busy weeks at Waikthlatingmayalwa digging up lungfish, preserving them in alcohol or formalin and soldering them up in zinc tubes which I had constructed in Paraguay, making injections of the blood-vessels, carrying on further observations on their habitats. In the interval we explored neighbouring parts of the Chaco inaccessible during the wet season and increased our knowledge of its general natural history. We finally left Waikthlatingmayalwa on 25th May and arrived at Buenos Aires on 13th June. As we had three weeks before our steamship was due to sail, we travelled South first to Bahai Blanca to spend a few days with friends who had an estancia in the neighbourhood. It was snowing heavily and we found the change from the warmth of Paraguay somewhat trying.

Thence to visit another old friend of Mate Grande days, Don Arturo Currie, who managed an estancia on the banks of the Quequen River. I had heard from him at Cambridge of his having found some fossil bones exposed on the banks of the neighbouring river, so, as the Museum of Zoology was completely devoid of specimens of the giant sloths[63], glyptodons[64], etc., belonging to the wonderful extinct fauna of the Pampa, I had begged Currie to do his best to get a representative set of these fossil bones for me to carry off when I visited him. He had got together quite a good collection and we were able to make considerable additions to it during our few days' visit. We spent a day packing the bones into boxes for our transport and were able to get them safely to Cambridge. After our return to Buenos Aires we made a little trip across the river to the Banda Oriental - Uruguay - to visit another old Mate Grande friend Walby. At dinner he astonished me by remarking that he had my old host, Don Benjamin Carbonnel, the once wealthy estanciero. working for him as a peon. He asked him to come in after dinner and it was indeed a shock to see him a complete wreck of what he had been as I had known him seven years previously, with his shrunken frame, his shambling movements and his timorous accents; the loud voice and the shocking language alike gone.

Arriving at Cambridge there came the task of unpacking the large mass of *Lepidosiren,* I imagine the most extensive set of embryological material of any particular vertebrate that had ever been got together. Everything was in perfect order and I must confess of feeling rather proud that, in spite of the rough handling during transport, there turned out to be not a single breakage among the many hundreds of fragile glass specimen tubes when I unpacked them at Cambridge (Fig. 8). Many congratulations were given to me on the wonderful good fortune which had enabled me to collect and preserve amid the remote tropical swamps of the Chaco one of the most complete series of developmental stages that had ever been obtained of any vertebrate, and to get it in perfect condition for investigation by up-to-date technical methods in the Cambridge laboratory. It meant that I had now to settle down to research that must last for several years.

Fig. 8. Jars of *Lepidosiren paradoxa* embryonic specimens, collected by JGK, and now in the Hunterian Museum collections.

I had already received word from Sedgwick that I was to be appointed Demonstrator in Animal Morphology, which meant that I was to be Head of the Junior staff in the Zoological - or as it was then called the Morphological - laboratory, and senior assistant to Adam Sedgwick. As colleagues in my teaching work I had Joseph Lister - nephew of the great pioneer of modern surgery, and Stanley Gardiner[65] who later became Professor of Zoology. My five years of teaching in Cambridge gave me invaluable experience, the more so owing to Sedgwick's time being much occupied by other duties, he had just been appointed Tutor of Trinity and in addition he was busily engaged in writing his great text-book of Zoology[66]. A result of these other demands on the time of my chief was that the main responsibility for the day-to-day running of the

department rested upon my shoulders.

While I had long realised how important it is for the quality of teaching in science that the teacher should be in close touch with research, I now began to realise how immensely the researcher is benefitted by having also to teach. There is nothing so effective in developing clarity of though as having to 'get across' facts and ideas to ignorant pupils. On February 9th 1898, there came to me in the laboratory a startling and wholly unexpected message - that I had just been elected a Fellow of Christ's and that I was to go at once to the College for the ceremony of admission. This marked the beginning of a delightful five years of residence in College. I was allocated a set of rooms on the first floor of Staircase B of the Fellow's Building. They had been vacated by their previous occupant early in the long vacation and on investigating with my pen-knife their linen-fold panelling covered with hideous yellow paint, I found it to be undoubtedly of oak, so I took the responsibility of engaging a firm of experts to remove the paint. This disclosed the beautiful dark oak panelling as it exists today, bearing the date 1644. There was a small grate surrounded by brilliant blue tiles and the removal of these disclosed the existence of the basal part of a carved stone jamb on one side, just sufficient to enable Messrs Rattee & Kett to provide a stone fireplace, much as it must have been originally.

Life as a Fellow of Christ's was very pleasant and stimulating: early breakfast in one's room, departure for the day's work in the laboratory, three hours' teaching; and then research up to about six o'clock. Dinner in Hall and then the Combination room until 9.15, commencing always with the Loyal Toast- uninterrupted since the days of the Stuarts. This record was unfortunately broken at the death of Queen Victoria, the announcement of which came while we were actually at dinner, and the presiding Fellow did not like the idea of drinking 'The Queen is dead, long live the King'. It was the duty of the junior Fellow to act as 'Nib' and keep the wine accounts. This was complicated by the fact that the unit of currency for the payment of bets or fines was a bottle of port. If a member incautiously remarked 'I'll bet so-and-so', without specifying a bottle of port, he was at once subjected to a fine. All such fines and bets had to be entered by Nib in the wine book, to remain there until cancelled by the Fellow responsible standing the particular amount of port as a contribution to the evening's wine. As the old wine books had been carefully preserved, it was interesting to see in them reflections of contemporary history - to read for example of bets upon the probable doings of Napoleon Bonaparte.

After dinner talk in the Combination room was always stimulating. "Shop" was strictly taboo - which I sometimes regretted for to myself the most interesting thing to listen to was the talk of someone about his own speciality, of which he knew more than other people. However, it had to be admitted that it would have tended to dim the sparkle of conversation among a set of able people. And such were undoubtedly the Fellows of Christ's. The Master was John Peile[67], a scholar of great distinction whose speciality was Comparative Philology. His ambition was to be the founder of a great school in this subject, and the rather embittered expression which his face was apt to assume in his leisure moments was commonly attributed to a painful experience he was said to have undergone. Each October term he had given a course of lectures on his special subject and at each inaugural lecture he was wont to scrutinise his audience in the search for someone who might betray by his expression possibilities in the direction of the school that was to be. Year after year, however, the scrutiny was in vain, until at long last he did descry a young man of obvious intelligence who seemed to be following the lecture with the greatest intentness. The lecture came to an end and the Master was gratified to see the young man staying behind to speak to him. What he was reputed to have said was 'Oh, please, Sir, I know this lecture isn't Algebra but is it Palley?'

Besides the Master the society included men of outstanding distinction in varied departments of learning: J.A. Sharkey, a Latinist of high repute; E.W. Hobson - later Sadlerian Professor of Pure Mathematics; W.W. Skeat, Professor of Anglo-Saxon; A.E. Shipley, that kindest of Tutors, a distinguished zoologist and later Master of the College; T.C. Fitzpatrick, physicist and later President of Queen's in succession to another Fellow of Christ's, F.H. Chase, later Bishop of Ely; Armitage Robinson, Norrisian Professor of Divinity and later Dean of Westminster; and Francis Darwin, Reader in Botany and son of Charles Darwin who himself had been, like John Milton in his day, a member of the College though never a Fellow. In a company illuminated by such a galaxy, with occasional visitors from other colleges or from Oxford or London, there were few topics that failed to arouse interesting discussions and it may be imagined what a pleasant ending such Combination room talk provided to a day spent in the specialized work of the laboratory.

Apart from my laboratory and college life, many of my most cherished memories centre round the homes of various Cambridge residents - above all those of J.J. Thomson, Professor of Experimental Physics, and C.S. Roy[68], Professor of Pathology. They were married to the twin daughters of Sir George Paget, F.R.S., a former Regius Professor of Physics, and in each of their households I was treated as if I were a member of the family. In the Thomson household was a delightful small boy, George, who used to amuse himself rigging boats or playing with Indian bows and arrows or fire drill. He was destined to be later on the famous Nobel prizeman, a leader in the world of Physics and Master of Corpus[69].

Another household of which I have pleasant memories was that of Francis Darwin[70] where I often used to dine. One of these dinners during my undergraduate days stands out in my memory. On my walk to his house, Wychfield, I was joined by another Christ's undergraduate, J.G. McCall, a cousin of James Frazer,

later of *The Golden Bough*[36], and at that time regarded as one of the confirmed bachelors of Cambridge. He gave me a bit of information which enabled me to explode a bomb among the large party of Dons and their ladies at Wychfield. When a suitable lull came in the conversation at dinner, I asked my hostess if she had heard the latest news of Mr J.G. Frazer of Trinity. 'No! Whatever is it?' 'He is going to be married.' Shrieks of 'Whoever to?' 'To the authoress of the Badminton volume on Dancing.' A stunned silence followed the reflection that she was in all probability a member of a *corps de ballet*. How very different when the reality became known to all who later on enjoyed acquaintance with the able and formidable Lady Frazer.

In those days Cambridge degrees were not open to women, although both Girton and Newnham were flourishing teaching establishments served by University lecturers. At Newnham the leading personality was Mrs Sidgwick, sister of Arthur and Francis Balfour. Her husband, Professor Henry Sidgwick[71], took a prominent part in University affairs. Like his brother-in-law, A.J. Balfour, he was appreciative of the fact that in public speaking a certain hesitancy increases the effect. On one famous occasion a celebrated German professor, invited after dinner to say something about his general impressions of England and its people, mentioned that one of the things that had struck him particularly was the apparent absence of what in Germany they called the 'gelehrte Klasse'. Sidgwick, commenting on his speech, remarked that the Herr Professor was mistaken in thinking we had no gelehrte Klasse in England. We had them but we did not call them gelehrte Klasse: we called them p-p-prigs.

My own chief, Adam Sedgwick, was strongly antipathetic to women students. One day I remember in the elementary practical class, Sedgwick was sitting down in the place of an undergraduate examining his dissections under a lens when he was approached from behind by Brocket, the laboratory attendant, accompanied by a Newnhamite. After coughing respectfully to attract Sedgwick's attention he said, 'Oh, please, Sir, Miss So-and-so of Newnham would like to speak to you.' 'Tell Miss So-and-so to go to the devil,' said Sedgwick without raising his head from the dissection, whereupon Brocket turned to the young person and said to her, 'Mr Sedgwick says will you please go to Mr Shipley.' When strong pressure was put on Sedgwick to modify his attitude he refused to do so, except to the extent of raising no objection to my accepting an invitation from Newnham to start a class for women students: this I did, but it had to be in premises other than the University department.

For the sake of my own research work, I had made a point of refusing to undertake private coaching and in agreeing to give a regular course of lectures and laboratory work in Zoology for students of Girton and Newnham, I stipulated that the arrangement should last only until I had found one of my pupils to be of a standard justifying my handing over the teaching to her. Such a one turned up in the person of Miss Igerna Sollas[72], daughter of the Oxford Professor of Geology. She proved an excellent teacher and also researcher.

My Cambridge memories are not confined to the academic terms. In the vacations, I was able to do a little sailing. For several reasons a little party of us chartered a 42-ton schooner from a Clare friend, J.A. Whish, and starting from the Thames cruised down Channel as far as Falmouth or Helford River. Our party was scientific but not biological, the others, E.H. Griffiths and F.H. Neville of Sidney, and the Earl of Berkeley, being all physicists. An earlier cruise, during my undergraduate days, was in the summer of 1895 when there came an invitation from my friend Hardy of Caius (later Sir William B. Hardy[73] - a pioneer in the chemistry of colloids, and Chairman of the Development Commission's Advisory Committee on Fishery Research) to join his 12-ton cutter yacht *Raven* at Kiel for the opening of the Kiel canal and form one of his crew in the voyage back to England.

Proceeding by rail to Hamburg, I crossed over to the Klosterthor station, filled with a struggling mass of people all bound for Kiel, and filling up a rapid succession of trains as quickly as they could be brought up to the platform. Into my own compartment I was accompanied by thirteen Germans with their impedimenta, and the journey to Kiel, lasting four hours over its proper time, in an atmosphere complicated by the smoke of thirteen cigars and the aroma of Schnapps, oranges and worse, was very unpleasant. At Kiel the hotels were all packed but I managed to get a room in a back street for the night. The *Raven* turned up a day later and anchored near the mouth of Kiel fjord. I spent the day pleasantly in a cruise around the fleets of the various naval powers in the steamer *Freia*, ensconcing myself undetected in one of the ship's boats from which I had an excellent view undisturbed by the crowds on deck. The Kaiser steamed along the lines of the fleet in his yacht *Hohenzollern* and it was aggravating to hear him greeted by each ship with the strains of our National Anthem - in those days regarded by the Prussians as theirs. In the evening the ships of each squadron in turn were outlined with coloured lights and there were magnificent displays of fireworks.

On Saturday, after shopping with Hardy and Brindley - the other member of his crew - I took up my abode on the *Raven*, from which on Sunday we had a magnificent view of the races of the Kiel Yacht Club, sailed in a strong wind which caused a good many broken spars and masts. On Monday a strong gale all day from the northwest gave us a good tossing and entailed constant watchfulness and the putting out of a second anchor as we were off a lee shore. On Tuesday morning the British squadron departed so we rigged up a tiny ensign on a boathook and saluted the flagship as she passed, our salute being duly returned. By the way, a strange incident occurred during the Kiel week which roused considerable talk at the time, in as much as daylight one morning showed that the French squadron had disappeared: it had sailed during the night without bidding its hosts farewell. Later on I learned privately

what lay behind this remarkable incident. It appeared that the Kaiser, when being shown over our Flagship, was allowed to try his hand at moving one of the turrets with its pair of big guns and he entertained himself by training them on the French flagship. As his every movement was being watched from the latter, this peculiar joke on the part of the Emperor was duly noted and stiffly replied to by the French Admiral's unannounced departure.

Early on Wednesday morning, 26th June, we entered the lock at Holtenau and spent the entire day in traversing the canal - reaching its further end about midnight. Our tug had four yachts in tow, all returning home from the Kiel celebrations, two of them English and one German, which latter was a nuisance through its violent sheering about, so we lengthened our hawser so as to drop astern and get out of his way. It was a bitterly cold day and a rather wearisome journey, though we could not but be impressed by the canal as a bit of engineering and by the magnificent railway bridges spanning it. Next day we explored the little town of Brunsbüttel, did some shopping, ate an excellent dinner, and about 6 p.m. emerged through the lock into the River Elbe. There we found a tremendous current and with it a favouring breeze: we rapidly made our way down stream and about 10 p.m. anchored just below the Cuxhaven lights. There followed three days of complicated navigation along the chain of islands bordering the North German coast - later the scene of Erskine Childers' famous story, *The Riddle of the Sands* [74]- during which my usual position was in the bows, heaving the lead and singing out the depths to Hardy at the tiller, while Brindley aloft in the rigging kept a lookout ahead.

Navigation was further complicated by very unsettled weather. During the first week in July it was so bad that we remained at anchor in the lee of the island of Ameland. On Friday the 4th, we spent a pleasant afternoon ashore having tea at a quaint little inn, the landlady in our honour putting on her best, including the beautiful gold headdress handed down from generation to generation and still to be seen in certain out-of-the-way parts of the Netherlands. After tea we walked out to the lighthouse and were shown over it - a climb of 200 feet. Far out to sea, we could view through the telescope an English 28-rater on her way back from Kiel. The keeper invited us into his house where we sat and talked, then back to the village and on board about 10 p.m. On the Saturday night, while cruising along outside Texel island on our way towards Niewe Diep, the Dutch naval port, we recognised while still far out to sea the strains of the music hall song 'Her golden hair was hanging down her back'[75] and on getting into port we found they proceeded from a steam organ here for the annual fair. The festivities centred in a circus of real ponies. They were mounted by bluejackets. At a particular bar the ponies started to walk, at another trot, at another to canter, at another stopped dead and the bluejackets fell off. The steam organ, the ponies and the bluejackets continued their activities all day without a pause and when we sailed on Monday morning, the strains of the steam organ followed us out to sea. From Niewe Diep we had a fine sail to Smith's Knoll lightship then round the coast into the Wash. A violent north-easterly gale necessitated our anchoring in the lee of a sandbank. Our anchor carried away during the night but we fortunately missed going ashore and when daylight came we were able to enter the port of King's Lynn and take the train to Cambridge. On other pleasant though less eventful cruises I sailed with Edmund Paget in his cutter *Cynthia* on the east coast and down the Channel and with the Roys on the Clyde and the Norfolk Broads.

One long vacation of my undergraduate period, that of 1894, I passed in the then delightful little university town of Jena, mainly to improve my knowledge of German, but also to get an idea of the workings of the zoological department of a German university. I stayed in the house of Frau Zeiss, a name already famous in connection with the manufacture of optical instruments. I was already familiar with the binocular eyepiece invented by Professor Abbé[76] as applied to the microscope but now I found the Zeiss works busily engaged in turning out field-glasses on the same principle. I was allowed to experiment with one and would dearly like to have carried it off. The firm had, however, been strictly prohibited from parting with any until the armed forces were completely equipped and this was not yet the case, so I had to wait several months before my wish was gratified. My days in Jena passed pleasantly and quickly. A.W. Rogers[77], a fellow undergraduate of Christ's - later a F.R.S. and Director of the Geological Survey of S. Africa - had accompanied me. We lodged in different parts of the town but Rogers joined me for an hour in the forenoon for German conversation under the auspices of Fraulein Zeiss and accompanied by three schoolgirl boarders. Our labours were often lightened by merriment caused by misunderstandings - not always involuntary - of German words or expressions.

Apart from our studies of the German language, we frequented scientific departments of the University devoted to our particular subjects. I naturally attended the lectures of Ernst Haeckel[78] who was then Professor of Zoology. His lectures were very characteristic. Heralded by his clattering down the stone staircase with a noise suggesting that he was coming down on a tea tray, he dashed at the blackboard with a lump of chalk in his right hand, writing a furious accompaniment to a torrent of words which continued almost without break until he dashed out of the room again at the end of the lecture. My most profitable time in Jena arose from a cordial invitation from Fürbringer[79], the Professor of Anatomy. The Department of Anatomy in a German university was not, as in an English one, restricted to the anatomy of man. The details of human anatomy as required by students of medicine were attended to by a special lecturer. In point of fact Fürbringer's position in the world of science rested upon his great work upon the anatomy of birds. As co-workers in his department were a number of other leaders or prospective leaders in the morphological side of zoological science; including Semon[80] and Braus[81] who were busily investigating the embryological material of the Australian lungfish

Ceratodus which the former had collected in Queensland.

I was treated with the greatest of kindness and allowed to potter about in the laboratory - reading German textbooks, examining the departmental collection of microscopic preparations, and above all inhaling the atmosphere of a very live university department. By comparison with Cambridge, two features impressed me particularly; one favourable - the far higher pressure of work all day long - the other unfavourable - the more proprietorial interest of the researcher in his own work. In the Cambridge laboratory everyone left his work scattered about, open to inspection by anyone; in Jena he locked it up when he left the laboratory.

After working hours Rogers and I would take a walk up one of the hills that surrounded Jena and have tea at the restaurant invariably to be found at its summit - Schweizerhöhe or the Fuchsthurm - overlooking the beautiful valley of the Saale. After dinner we usually adjourned to Die Sonne and drank beer while we listened to the music of Wagner. Jena - in close proximity to Weimar - was naturally dominated in those days by the music of Wagner and Liszt. Certain evenings we spent with the Naturwissenschaftliche Verein - the students' science club - and were inducted into the ways and laws of the Kneipe or Bierabend, ending usually in the small hours with a visit to a cellar in which was prepared a soothing and seductive Knickerbein - a glass of dark liqueur on which floated the yolk of an egg.

A different type of diversion from our laboratory studies was afforded by the students' duels - more correctly Mensur, the German term Duell being restricted to the settlement of questions of personal honour, whereas in the Mensur the two antagonists are merely representatives of rival student clubs. Of these, there were in Jena three categories, the Corps, the Burschenschaft and the Landsmannschaft. Our more intimate friends belonged to the Burschenschaft 'Germania', and its Mensurs were with representatives of the rival Burschenschafts 'Teutonia' and 'Arminia'. The Mensur was held in a large first-floor room in a country inn a couple of miles from Jena. As we approached it about 8 a.m., our ears were greeted by the clash of swords and the occasional shout. We found the proceedings in full swing. Each Burschenschaft was represented by a team of four: the principal, a friend of the principal, a second and a doctor with his equipment. The weapons used were light swords, unpointed and with razor-sharp edge. The two contestants had the front of the body, throat and right arm protected by thick padding and their eyes by goggles. The seconds wore similar protection on their right arm and head. At the commencement of the Mensur the two principals took up their position one sword-length apart, the right arm of each supported by his friend, and the second stationed on the principal's left. At the word to commence the friend withdrew his support, the principals crossed swords and at a second word went at it hammer and tongs, showing very pretty sword play, entirely from the wrist, and of course entirely different from fencing with foil or épée. After about four or six cuts and parries, the seconds struck up the opponents' swords while their friends seized and supported their right arms to give them a rest.

So the Mensur went on, round after round, at first in rapid succession, later with longer intervals, with increasing weakness from fatigue and loss of blood. In the absence of serious wounds each pair was supposed to fight for fifteen minutes. In point of fact, the first contest lasted nearly an hour: others were much shorter: one no longer than three minutes when it was terminated by a neat cut slicing off the flesh from one side of the head with the greater part of the ear, necessitating immediate surgical attention. In any case the fifteen minutes was interrupted at half time for a five minute rest. The two doctors were on watch throughout, ready to stop proceedings the moment a bad cut necessitated their attention. The Mensur seemed a strange substitute for the relaxations of English undergraduates but it had its points: its training in quickness of hand and eye, in indifference to pain, and insubordination of personal interest to that of the Burschenschaft. One learned to understand how the much-scarred face one so often saw in Germany in those days was appreciated as a certificate of the hard training its bearer had been through.

Glasgow, 1902 – 1935

In the year 1901 I began to hear rumours of an impending vacancy in the Chair of Natural History in the University of Glasgow. I had regarded that as the ideal setting for my life's work ever since I had decided to devote my life to Zoology. In the first place, its proximity to the Firth of Clyde, where I had spent so many of my pre-Cambridge days dredging and tow-netting, offered a marvellous vista for research work on marine zoology. In the second place, the Glasgow Chair of Natural History had been occupied since the year 1866 by a geologist, and his successor would have the fascinating task of creating an up-to-date Department of Zoology from the very beginning, untrammelled by grooves worn by his predecessor. At the same time, I had to realise that, apart from its personal appeal to myself, the Glasgow Professorship with its relatively high emoluments and its long summer holidays, was generally regarded by professional zoologists as one of the most attractive in the country and the vacancy would certainly mean a large field of candidates. Nevertheless I decided to have a try for it in spite of my comparatively junior status, so I proceeded to draw up a letter of application and collect testimonials. It was not until well on in the summer of 1902 that I gathered that the appointment was imminent, and on July 29th I forwarded my application to Lord Balfour of Burleigh[82], Secretary for Scotland, the Minister responsible for advising the King regarding Regius appointments in Scotland.

On Saturday, 2nd August, a letter arrived from Lord Balfour suggesting a personal interview on the following Friday. During that interview it became obvious that Lord Balfour, in accordance with his

reputation, had taken a keen personal interest in the forthcoming appointment and he seemed to know all about my previous career including my early morning walk from Dalkeith to the Botanic Gardens, Edinburgh, to attend the 8.0 a.m. Botany class, my two expeditions to the Gran Chaco, and my time at Cambridge. However, he put me through a searching examination which unfortunately brought out a violent divergence of opinion on certain fishery matters. He became quite heated, kept the Duke of Sutherland waiting ten minutes in the corridor, and when at last Lord Balfour bade me a rather stiff farewell, I felt that I had better give up all thought of Glasgow possibilities. It was therefore a most unexpected surprise when I learned on the following Wednesday that my name had been sent to the King. Absolute secrecy was imposed upon me until the official announcement of the appointment in the newspapers, and there ensued a somewhat difficult period during which I had to keep my secret inviolate even to my nearest friends and relations, and benignly accept the condolences of those who had heard definitely that the appointment had gone elsewhere. After the King's approval had been given, I had a delightful letter from Lord Balfour conveying his good wishes and assuring me that a warm welcome awaited me in Glasgow - above all from F.O. Bower[83], Professor of Botany, the subject most closely linked with my own.

The public announcement on 19th August brought me a flood of congratulations and good wishes - some of the letters betraying a little surprise that so important a professorship should have been entrusted to one so young and comparatively inexperienced. Answering these and winding up my Cambridge affairs kept me busily occupied for the next week or two. A pleasant incident was the offer by E.J. Bles[84], a Cambridge zoologist a good deal senior to myself and with very wide knowledge of the subject, to accompany me to Glasgow as my demonstrator. My appointment at Glasgow was from 1st October, 1902, and since the period of my appointment as Demonstrator at Cambridge expired at midnight on 30th September, I had no period of unemployment.

Passing through Glasgow on my way to Lamlash, where I proposed to spend a quiet month working on my first term's course of lectures, I took the opportunity of making reconnaissance of my future department. There was, of course, no zoological laboratory. The eastern half of the lower hall of the Hunterian Museum - know in later years as the Hunter Hall - had been used for what little practical work had been done, but it had no scientific equipment. Its floor was littered with geological debris: its entry was by wooden steps through one of the windows. A startling discovery came when I examined some old furniture which had been carried out into the quadrangle preparatory to being broken up. Amongst this was a decrepit chest of drawers, and pulling out the drawers I found the bottom of each studded with insects with old dusty labels, so I told the Master of Works, who was showing me around, that this chest of drawers must on no account be destroyed, but must be carried back into the shelter of the department to await my taking over at the beginning of October. I may say that my examination of the labels in these drawers showed that here was the long lost Hunterian Collection of insects which had been worked through, arranged and labelled by the great entomological pioneer, Johann Christian Fabricius[85], and which contained over 200 of the original type specimens on which Fabricius had based his definitions of species. Such type specimens of Fabricius - and of other early entomologists also contained in the Hunterian Collection - were of course irreplaceable and priceless in value. Their original descriptions were still extant in the published works of Fabricius but the actual specimens had disappeared and it was a great discovery to find them still in existence. It was pleasant too that my first adventure in Glasgow was to save them from destruction. Later on they were submitted to skilled examination by Dr R.A. Staig[86] and their descriptions brought up to date[87] (Fig. 9).

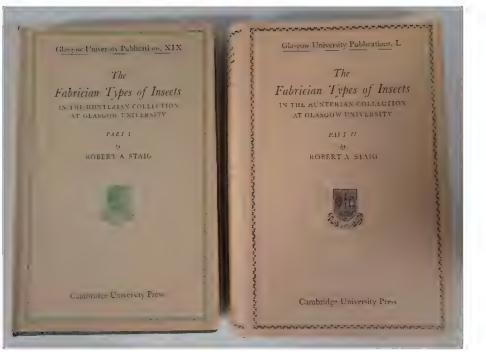


Fig. 9. Covers of R.A. Staig's two volumes on the Fabrician insect specimens in the Hunterian Museum collections.

My time in Lamlash was busily occupied in planning my first term's course at Glasgow. The great majority of my students would be entrants to the curriculum in Medicine, so I was determined to model my course in such a way as to make it provide as sound as possible a foundation for later subjects in the curriculum. To achieve this I decided to break adrift from the type of course in Elementary Biology customary in other medical schools. It was usual to commence the animal section of such courses with the dissection of a vertebrate such as a rabbit. This type of course, when first introduced by T.H. Huxley[88], had marked a great advance, but I learned when teaching it at Cambridge to appreciate its fundamental defect as a means of starting the ignorant beginner on a curriculum concerned with the human being. In its main features of structure and function, a rabbit is a creature of very much the same grade of complexity as man, whereas the proper introduction of the elementary student to the study of animal life would surely be by way of an animal organism of the least possible complexity. Pre-eminent among such creatures is the little protozoon, *Amoeba proteus*. The adoption of *Amoeba* as the first animal to be studied by the elementary student would clearly involve practical difficulties - training in microscopic

techniques, the obtaining of *Amoeba* in quantity, and in the actual teaching, but I decided that none of these difficulties was insuperable.

The main conclusions I came to in planning my course were: first, that it should commence with a concentrated study of *Amoeba* to make the student familiar with the structure and functions of a typical animal cell; second, that in my survey of the animal kingdom I should so far as possible confine myself to those of its members that illustrate important principles and to those which are of particular importance to medical science; and third, that I should leave the teaching of the special anatomy and physiology of the mammal to the University departments of Anatomy and Physiology, where it could be done properly instead of by a hurried scramble through the anatomy and physiology of the rabbit in the short time available in the course of Zoology. The carrying into effect of my plans would necessitate the provision of expensive new microscopical equipment and I had to take the drastic step of refusing to start my practical class - compulsory by Ordinance on all students of medicine - until this was provided. Happily, the Principal of the University, Dr Herbert Story[89], played up excellently: the money was obtained from a special fund, and the new practical class was duly held after a delay of only one term. My departure from what was customary in other medical schools found little favour among my zoological colleagues. How absurd, they suggested, that elementary students with no knowledge of microscopic technique should be entrusted with valuable high-power microscopes and still more valuable - it might be irreplaceable - microscopic specimens. As a matter of fact, experience showed that the Glasgow students reacted splendidly to the responsibility placed upon them, and the cases of serious damage to microscopes of specimens during my thirty-three years of office were exceedingly few. It was delightful to witness the thrill of excitement of students as they watched, say, living trypanosomes wriggling about in still living blood. I was to have the strange experience later on of medical men who had been though my course urging its extension in spite of the limitation in length of the medical curriculum.

While the main teaching of the courses in Zoology had to be carried out in lecture room (Fig. 10) and laboratory, a necessary supplement was a museum for the display of specimens of importance other than those studied in the laboratory. A teaching museum had to be created. It is true there existed the great Hunterian Museum - the collections bequeathed 'to the Principal and Professors of the University of Glasgow' by William Hunter[90]. My four predecessors in the Chair of Natural History had each in turn occupied the post of Keeper of the Hunterian Museum, but such an additional responsibility seemed quite out of the question for me in view of the task lying ahead. I therefore proposed to the Museum Committee - a body composed of the Professors of Natural History, Anatomy and Geology along with two representatives of the University Court and the Principal as Convenor - that the Keepership of the Hunterian Museum should be replaced by

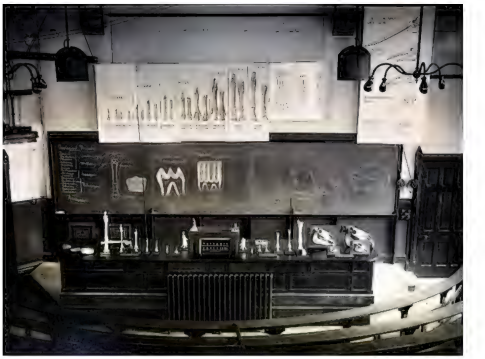


Fig. 10. Original Zoology lecture theatre in Glasgow University's Gilbert Scott building, ready for JGK to lecture on mammalian limb skeletal anatomy. Image courtesy of University of Glasgow Archives & Special Collections, John Graham Kerr collection, GB248 DC6/1230/4).

Honorary Curatorship. This was agreed to and approved by the University Court and I became Honorary Curator of the zoological collections. These included the Hunterian Collection of Insects, valuable type specimens of corals, and the valuable Waddell Collection of bird skins from Tibet[91]. The zoological exhibition cases were filled with stuffed birds and mammals - a large proportion of them in very bad condition, and obviously of little value for teaching purposes.

To create an adequate teaching museum of Zoology would involve the expenditure of much money and much skilled labour. As regards the former, there were no university funds available but a beginning was made when a local body - the Bellahouston Trustees[92] - agreed to make a grant of £500 conditionally on the University Court providing a similar sum. The Court agreed to do so and my first measure was to instal specially designed exhibition cases of steel fitted with internal electric lighting and dust filters to safeguard against the grimy Glasgow atmosphere. I had also the good fortune to recruit to my staff an enthusiastic and highly qualified expert in museum technique - R.A. Staig[86].

The development of the teaching museum provided perhaps the most fascinating part of my work in Glasgow. I started with pronounced personal views moulded by my previous experience. I had long felt that museums in general suffered by the crowding of their exhibits. An isolated specimen on a shelf by itself at once attracts attention: a crowded series of specimens is apt to be passed by. I therefore made a rule to restrict the exhibited specimens to the few that conveyed some definite lesson. The mass of the museum collection should not occupy the valuable and restricted exhibition space, but be stowed away in store cabinets. This applied more particularly to fragmentary fossils. To demonstrate the characteristic features of the skeleton of an extinct vertebrate, the effective method would be to exhibit not isolated fragments but rather a reproduction of the most

perfect known specimen when that could be obtained by purchase or exchange.

My experience of tropical nature had caused me to develop a particularly keen interest in the colouration of animals – usually adaptive as an aid or obstacle to their recognition, though sometimes of no obvious biological significance – as in the case of various animals inhabiting the depths of the ocean where no daylight penetrates but which nevertheless show brilliant colours when brought into daylight. Apart from their personal interest to myself, it was obvious that the colours and colour patterns of animals provided material of much value in the teaching of natural history and therefore demanded special attention for their display in a teaching museum. The two main requisites would be: first, lighting – adequate for display while safeguarded against the bleaching induced by prolonged exposure to intense daylight, the disastrous effect of which I had seen in other museums; and second, a background suitable to show up the colouring to the greatest advantage. Much experimentation convinced me that dead black was on the whole the most effective background, and the most perfect black was provided by the finest quality of black silk velvet. This was expensive, so its use was restricted to the showcases of comparatively small dimensions, while the larger exhibition cases were provided with a background of the most perfect obtainable matt black varnish.

The Bellahouston grant made it possible to proceed slowly with the museum programme, but by 1911 it was exhausted and the problem was how to finance the continuation of the work. Fortunately the then Principal, Sir Donald MacAlister[93], who regularly presided over meetings of the Museums Committee and was keenly interested in my development of a teaching museum, agreed to include in a forthcoming appeal to Government for an increase in the Annual Grant to the University, an additional sum for museum expenditure. The appeal was successful and on 25th June, 1913, the University Court agreed to the allocation of £1600 of the new grant to museum purposes. On February 4th, 1914, the Finance Committee agreed to its allocation in detail: cases and furniture £600, Zoology £500, Geology £250 plus £150 for a new Curatorship, Archaeology and Anatomy £100. As the whole incentive to the new grant had come from the needs of Zoology, I did not view with enthusiasm the diversion of a large proportion to the Department of Geology but I thought it wise to refrain from making difficulties – more especially as the amount allocated to cases and furniture must obviously go in great part to Zoology in view of the high cost of the specially designed steel cases. These cases with their walls and shelves of glass were practically air-tight, the unavoidable slight exchange of air between interior and exterior taking place through a filter of cotton wool so as to block effectively the entrance of dust with the in-draught. Their lighting was provided by tubular electric lights enclosed within the cases so as to avoid the view of their contents being interfered with by reflection from the front of the case. The lighting of each individual case was controlled by a switch so as to avoid wastage of electricity when the case was not in actual use.

The main purpose of the teaching museum was the exhibition, properly displayed and labelled, of such members of the animal kingdom as were of special importance from either the purely scientific or the practical point of view. The acquisition of these involved getting into touch with dealers, naturalists and museums – it might be in some distant part of the world. Although a large proportion had to be obtained by purchase, others were got by exchange and my unique material of stages in the life history of archaic vertebrates such as dipnoan and ganoid fishes had, of course, a very high exchange value. Some of the most interesting acquisitions were specimens of parasitic animals of medical importance which came as gifts from former students. Museum developments were naturally interfered with by the First World War but at least one specimen of great value came as a result of the outbreak of war. This was a magnificent skeleton of a gorilla which had been prepared in Paris for the German government by the great expert of that time in the preparation of bony skeletons. This patriotic Frenchman let me know of his readiness to do a deal over this skeleton and it reached Glasgow in due course. (Fig. 11) The active growth and development of the teaching museum together with great increase in the number of students made more and more urgent the problem of adequate accommodation of the Zoology Department as a whole. The accommodation so far had been ridiculously inadequate. On 22nd September, 1912, I had a special interview with the University Court to emphasise the impossible conditions under which the work of the department was being carried on. The Court were most sympathetic and I was authorised to discuss possibilities with the eminent architect, Sir John Burnet[94]. It was obvious that the complicated needs of up-to-date teaching and research demanded an entirely new building adapted to those needs, and it was further clear that the building should be remote from the roadways bounding the University grounds to ensure freedom from the risk of high-power microscope work being interfered with by vibration caused by the passing of nearby electric trams. It was further important that it should have open ground to the north so as to ensure steady northern light for dissecting and microscope work. In May, 1914, the general idea was approved by the University Court; the new Zoology building to lie on the southern side of a wide western quadrangle with the existing Natural Philosophy building on its eastern side and the contemplated Chemistry building on its northern side.

The working out of detailed plans went steadily ahead, the accommodation for research and practical classes being concentrated along the north front and special precautions being taken to secure good lighting for the back benches in the large rooms required for the elementary practical class by carrying its windows right up through the full height of the building. It was an era of great development in the technique of cinematographic and other methods of projection, and the Glasgow department made full use of these. A

Fig. 11. Skeletons of an orangutan (left) and gorilla (right) in the Hunterian Museum: the gorilla skeleton was purchased by JGK.

powerful projection apparatus by Zeiss was installed capable of showing on the screen not merely ordinary lantern slides, but microscopic preparations under a magnification of many thousands of diameters so as to display clearly the peculiarities of minute microbes or the details of tissues as shown in microscopic sections of more complex animals. An important adjunct was the episcopic arrangement for displaying on the screen opaque objects such as corals or shells, or drawings or book illustrations.

In the design of the new building there was included a full-size projection chamber for cinematograph films. It happened that this coincided in the time with an immense growth of the cinema industry and I was able to obtain from Messrs Pathé at comparatively small cost a full size projection apparatus of a type which they were replacing by one better suited for the hard wear of public cinema. By gift and purchase a fine collection of films were got together including the Rockefeller[95] films detailing with the fights against malaria and hookworm disease. It became at once obvious that the cinema provided a splendid addition to the technique of zoological teaching, but practical experience brought out its weakness as compared with the old-fashioned method of wall diagrams or drawings on the blackboard, the hurried view of the moving film being admirable so far as it concerned gripping the interest of the student, but on the other hand, a comparative failure so far as it concerned impressing details upon the memory.

Accordingly, my teaching method reverted to the use of diagrams, more especially drawings on the blackboard during the lecture, while cinema was restricted to Saturday forenoons. Though the attendance then was voluntary, the students very soon began to understand that it was well worth while from its effect in livening up the picture of complicated details at which they had laboriously worked during the week. In one section of the subject, that dealing with animal movement such as the flight of birds, the cinema – more especially 'slow motion' films – retained its place in primary teaching.

When interested in the use of ordinary lantern slides, my thoughts naturally turned towards the possibility of stereoscopic projection and I thought out a new method, making use of carbon process in which printing on a film of gelatine sensitive with bichromate results in a picture expressed in relief by varying thickness of the gelatine film. To make the picture visible it has be to dyed, and it seemed to me that to obtain a stereoscopic picture on the screen all that was necessary would be to stain, say, the right eye picture green and the left one red, to superimpose two pictures on the glass lantern slide, and then to view the blurred result on the screen through spectacles, the right eye green and the left red. The viewer would then see the right hand (green) picture though his right eye and the left hand (red) picture though his left eye and the result would be a perfect stereoscopic picture. I proceeded to test my idea experimentally and found it worked perfectly and felt much set up. But alas! I discovered that I had been forestalled in Germany and Messrs Lilienthal of Düsseldorf sent me an album of stereoscopic landscape pictures prepared on this principle with accompanying spectacles of red and green gelatine.

A small detail that I found useful in my lecture room teaching was to have two pointers – the one matt black for use with ordinary diagrams, the other white for use with lantern projections – the pointer itself disappearing from view and its black shadow being used in its stead. In the general planning of the new lecture room it was necessary to bear in mind the importance of the entire audience having a clear view of illustrative specimens placed on the lecture table and in accordance with this, I arranged with the architect that the benches should be concentrically curved and that the upward slope of the floor should increase in steepness towards the back of the room. In connexion with these arrangements, the steel framework to support the floor presented an impressively complicated appearance before it was covered in by the wooden flooring.

The planning of the new museum building was dominated by its primarily teaching function. An ordinary public museum has to be adapted for indefinite

growth as its collections increase in size. Not so a teaching museum, which should be restricted in size if it is to remain effective in stimulating the keenness of the student. It has to keep in touch with the teaching of the day, specimens which have become less important being weeded out to make way for others whose importance has increased. It was decided to place the museum at the south-west corner of the new building: one storeyed, the day lighting to come from the roof. Experience of the destructive effect of intense daylight in other museums enjoined that this must be guarded against. To do this, each roof light was divided into a number of vertical cells, their depth being just sufficient to exclude direct rays from the sun when at its greatest altitude in midsummer. Each cell was painted white, the result being a soft diffused light in the interior of the museum. Artificial general lighting was given by 'day-light' lamps of the pattern used in up-to-date business premises, but the really important lighting from the practical point of view was that of the individual cases by the tubular lights inside the cases.

An important detail, as in all museums, was that of labelling. The two faults to guard against were in the first place too great detail, which would encourage the student to cram up a superficial knowledge from the labels and discourage the more important work of lecture room and laboratory, and in the second place illegibility when not strongly illuminated. The latter difficulty necessitated much experimentation. White lettering on a black background was obviously better than the usual black on white, but many trials failed to discover a white pigment that could be depended upon to retain its brilliance in the Glasgow atmosphere. Eventually it became clear that the most perfect labelling was by using bookbinders' gold leaf on a matt black background and this was finally adopted. The labels were printed with ordinary printer's ink on matt black paper and the gold leaf, applied immediately, adhered strongly to the letter, the non-adherent portions of leaf being carefully dusted off when the ink was dry.

This new technique in museum labelling involved me some years later in an amusing controversy with H.M. Stationary Office which had been asked to adopt my method by one of the great public museums. If the application were granted, the Office replied, it would be repeated by all the other museums and the expense would be enormous. Evidence that the cost was very small owing to the extreme thinness of the pure gold leaf used by bookbinders produced no effect, but as there could be no denial of the outstanding degree of visibility of the gold label, it was agreed that the museum in question could have its labels printed in 'gold ink'. When it was pointed out that the so-called gold ink was really not gold and that the brilliance of labels printed with it would soon tarnish, it was agreed that six copies of each label would be printed so that there would be five in reserve! Another complication had to do with the artificial heating of the museum which was liable to undergo violent changes of temperature and this in turn, by causing changes in volume of the fluid contained in museum jars, brought about both loss in volume and diminution of the strength of the preservative fluid when alcoholic. To avoid this waste, it was decided to instal thermostatic control. In addition to the museum itself there were included in the plan rooms for printing and other technical work, ample cellarage accommodation, animal houses, an aquarium room, and library in which I installed my private collection of zoological publications to form a departmental library.

I had learned to appreciate, both at Cambridge and during my earlier years in Glasgow, the difficulty of ensuring that students make full use of the museum, so in planning the arrangements of the new building, I devised a means of entrapping them into involuntary visits to the museum. This was done by arranging a wide communicating door between the museum and the large elementary laboratory. This door alone was opened at the hour of commencement of the practical classes, so that all students had to enter through the museum. Those who arrived a little before the hour had to wait in the museum and quite naturally a large proportion became interested in what was to be seen there and tended to develop the museum habit. As I thought it a part of my duty to encourage interest in the natural history of our own country apart from formal teaching I did my best to get together an index collection of our British birds and mammals and this was arranged along the west side of the museum.

I have given an idea of the planning of the new Department of Zoology, but its translation into stone and lime was prevented by the First World War. It was not until March 1919 that the Court decided to go ahead. Early in 1921 came final approval of the detailed plans. In July of that year the foundations were laid and by midsummer 1923 I was able to envisage moving into the occupation of lecture and practical class rooms at the beginning of the Winter session. I interviewed the contractor who promised that it would be ready by the end of August. I said 'You can have till the end of September but I will count on its being ready then as my first lecture will be on October 8'. On 7th October I looked into the lecture room: there were no benches. I reminded the contractor that I was going to lecture tomorrow. 'Quite impossible!' However, I proceeded to my lecture room at 9 a.m. on that morning and found the room well filled, the students all seated on the floor, with anticipatory grins on their faces. I gave no indication of noticing anything unusual and proceeded with my normal introductory lecture on *Amoeba*, to which they were most attentive. However, I stopped five minutes before the usual time and made a few remarks on the subject of contractors. They were, I said, an unhappy race: no one seemed to appreciate them; and I suggested that anyone with access to a telephone might ring them up (I wrote their telephone number on the blackboard where it remained all through the week). That would let them know there was at least some interest in their work and it would give them the heart to carry on. I gathered that the students played up admirably and that the contractor's telephones were kept ringing from morning to night. That they were duly encouraged to get on with their work seemed to be evidenced by the high pressure

at which they now strove to get the benches completed. Although several months had to elapse before its fittings were complete, the museum itself was finished very soon after the rest of the building, and proved a great architectural success both as regards suitability for its purpose and artistic beauty. It formed a wonderful setting for the Rectorial luncheon[96] on 12th December.

The Professorship of Natural History to which I was appointed in 1902 may be said to have originated in the Lectureship in Natural History founded in 1803. In 1807 the Lecturer, Lockhart Muirhead[97], who had previously been University Librarian, was given the task of superintending the packing and transmission to Glasgow of the great collections formed by William Hunter, brother of John Hunter who had founded the Hunterian Museum in London. In the same year (23rd March 1807), a royal warrant was issued appointing Muirhead Professor of Natural History and Keeper of the Museum. The creation of this, the first Regius Professorship in the University, without previous consultation with the University authorities, was the cause of considerable excitement and it was not until December 1808 that Muirhead was formally recognised. One clause in the royal warrant of my appointment caused me great regret. 'If and when a separate Chair or Lectureship of Geology should be founded in the said University, the said Professor shall cease the teaching of Geology and the Professorship of Natural History shall be styled the Professorship of Zoology'. The objectionable phrase was that enjoining the change in title of the Chair, for, apart from the fact that 'Natural History' was in ordinary use as the equivalent of zoology, the old title had been continued in the case of the corresponding Chairs of the other three Scottish universities in spite of the fact that the teaching of Botany and Geology took place in separate departments[98].

Throughout the planning of my courses in Glasgow, as of the building which was to house the department, I took the view that the Professor's duties were concerned with zoology in the broadest sense as the basic science of animal life. Specialised sections came under the responsibility of the independent Agricultural and Veterinary Colleges and that arrangement I regarded as excellent. At the same time there was no getting over the fact that the great majority of the students passing through the Department of Zoology did so *en route* to a Degree in Medicine. It was accordingly a primary responsibility of the department to provide a sure foundation upon which could be built the more specialised courses of the medical curriculum. In planning my class for the first term of the academic year, I tried to bear in mind that while adequate as a general introductory course in zoology, it must have special regard to the claims of the medical students. In accordance with this I endeavoured, so far as possible, to make use of animal types that were of special importance to medical science, such as parasites and pathogenic microbes.

I had further to bear in mind that a large proportion of the students coming straight from school had had no training whatever in observational science. It was therefore a further responsibility of my department to do what it could in the way of training the powers of observation. In view of this the course should be on the whole morphological – dealing with facts of structure that can be observed and recorded by being drawn in the student's notebook. Incidentally, such work would involve training in the technique of dissection and microscopic observations – both essential in later stages of the curriculum. In view of the short time available (50 meetings of the class) it was impossible to include theoretical aspects of Zoology such as evolution, heredity, variation and so on. However, I arranged to make available a set of special lectures on these at hours which did not clash with those of the ordinary class and which would be freely available to present or past students.

When the day arrived for my first lecture, the Principal proposed to be present to introduce me formally to my students, but from my knowledge of Scottish students I decided to tackle my first contact with them independently. It was in some trepidation that I entered the crowded classroom. There was a little disturbance at first as they "tried it on" with their new Professor but it very soon died down, those who had come mainly for fun slipped away by the door at the back of the room, and those who remained listened with rapt attention. And so it remained during my 33 years of office, my students formed a perfect audience, not a sound unless I perpetrated some 'howler' when at once shuffling on the floor emphasized the fact that they were following every word. In pre-war years their capacity for making a noise showed itself in community singing – sounding as if it would lift the roof off but ceasing at once as I stepped on to the dais. I was indeed extraordinarily fortunate throughout in my relations with my students: and my keenness to teach was amply reciprocated by their keenness to learn.

University teaching extended through the three academic terms – the first two being grouped together as the winter session. The introductory course in Zoology occupied the first term – lectures one-hour daily Monday to Friday, practical classes two hours daily. During the other two terms, some advanced courses were given on various sections of the animal kingdom. Attempts were made to get me to attenuate the elementary course by reducing the number of meetings per week, leaving the full number to be made up in the second term. To do this would have made it easier for the teaching staff by reducing the extreme pressure during the first term, but I held out against it as keeping the pressure lighter during the second and third terms made it easier for the staff to find time for research. I still held to the view that being a researcher made a better teacher and that being a teacher made a better researcher.

The efficient running of a large university department is in great part dependent upon its junior staff and in this I was extraordinarily fortunate. In the early days E.J. Bles, who accompanied me from Cambridge, and for a short

time W.F. Lanchester[99], gave me most devoted assistance. Bles had not only a profound knowledge of the literature of Zoology but was an able teacher and researcher. His one failing – from which I was not entirely free myself – was that he was apt to lose interest in a particular bit of research when once it was completed. He had much less interest in seeing that his results were published and made available to others.

W.E. Agar[100] of King's College, Cambridge, had attracted my attention during my last year as Demonstrator and I was fortunate in inducing him to come to Glasgow. He achieved classical research on the reproductive cells of *Lepidosiren,* followed it up by a long series of investigations bearing on heredity and genetics, and eventually left Glasgow to occupy with much distinction the Chair of Zoology at Melbourne. My own personal interest throughout my career as a zoologist had continued to lean towards 'primitive' or archaic types of animal life: creatures that had lagged behind in their evolutionary progress. It was natural then that the Protozoa[101], the least advanced of all the existing sections of the animal kingdom, should play an important part in both teaching and research in my department.

Charles H.G. Martin[102] concentrated on a particularly obscure section of the Protozoa – the Acinetaria – and added greatly to our knowledge of them. His brilliant research career was cut short by his untimely death during the First World War. A similar end came to J.S. Dunkerly[103] who had recovered sufficiently from a severe wound to resume his research work but only to die a few months after his appointment to the Zoology Chair in Manchester through a flare up of the infection of his old war wound.

Apart from its actual teaching staff the Glasgow department was associated with two dramatic developments in the history of protozoology. Muriel Robertson[104], who commenced her research career in the department, specialised in the study of parasitic Protozoa and was able in a stay of several months of Mpumu in Uganda, to do much to complete the imperfectly known life history of the trypanosome which causes sleeping sickness. She had the distinction at a later period in her career of being the first woman zoologist to be elected to the Fellowship of the Royal Society (Fig. 12).

The other somewhat dramatic occurrence had to do with teaching. My course commenced with the detailed study of *Amoeba*. During pre-war years the most reliable purveyor of live amoebas was one Thomas Bolton of Birmingham who became latterly dependent on a son for the collection of the amoebas. Young Bolton's departure for the war meant an immediate slump in the supply of amoebas and the practical work of my class threatened to be entirely held up. It had happened that among the former students of my department who had greatly distinguished themselves were three nuns of the order of Notre Dame. They had developed a remarkable science department at their training college at Dowanhill,

Fig. 12. Muriel Robertson F.R.S. (Photo: Department of Zoology Archives/University of Glasgow)

Glasgow, and I appealed to them for help in this emergency. I asked them to make a special study of the haunts of *Amoeba* in the neighbourhood of Glasgow, to find out what were the conditions under which they flourished so that knowing these they might be able to run an 'amoeba farm' and keep a constant supply of amoebas which would be always available to the meet the teaching needs of our department. They took up this task with enthusiasm and with complete success, so that for each day on which we were doing *Amoeba* in the practical class, instead of the few small specimens we were accustomed to get from Thomas Bolton, we were able to have available hundreds of large healthy amoebae whenever they were required. Soon after the end of the war an exhibit of a Notre Dame culture of *Amoeba* was shown at a soirée of the Royal Society in London and excited much attention. Sir Ray Lankester, looking down at a culture through a binocular microscope, said it was like looking down on a meadow with cattle grazing.

Dr Monica Taylor[105] (Sister Monica S.N.D.) who had played the chief part in working out the conditions favourable to the life of *Amoeba* developed methods of rearing and cultivating them which became widely adopted in university departments all over the world. In her own department they played a great part in her long series of pioneer researches upon the life history of different species of *Amoeba*. Certain species of the genus *Amoeba* have taken to a parasitic mode of life, one being responsible for amoebic dysentery in man, and another member of the University department, Dr

Margaret W. Jepps[106], played an important part in the advancement of knowledge of this and other parasitic amoebae.

In 1923 came an important recruit to the staff, G.S. Carter[107] of Caius College, afterwards Fellow of Corpus College, Cambridge. He made an expedition into my old haunts in the Gran Chaco and made a very valuable study of the conditions affecting life in the great swamps of that region. In addition to his general studies, he made important additions to scientific knowledge of the special arrangements for breathing air which enable the fish of these swamps to cope with dry season conditions when gill breathing becomes impossible. Other members of the junior staff who carried out research work of interest were R.A. Staig who concentrated upon the study of the Hunterian collection of insects and Miss A.E. Miller[108] whose work on the lower vertebrates included a study of the evidences that the curious little fossil *Palaeospondylus* of supposed lamprey affinities was in actual fact more nearly allied to the lungfish of the primitive vertebrates.

Apart from the formal duties of the University Professor to teach his own students there lay the further though informal duty to do his best to spread interest in, and knowledge of, his subject in the community outside. I was given plenty of opportunity to this by the frequent invitations that came to me to address Natural History[109] and other Societies in Glasgow, Greenock, Paisley and other centres. The opportunity of organising such work on a more extended scale arose when in the autumn of 1920 a letter came to the University Court announcing that the Workers' Educational Association was about to start a branch in Glasgow. On my advice it was decided not merely to let the letter lie on the table but to send a message of good wishes and to agree to the invitation to appoint a representative on the local committee. I was appointed and became Vice-Chairman of the Glasgow W.E.A. My period in that office was most interesting and in spite of the strongly socialistic views of my colleagues I managed to maintain an atmosphere quite free from party politics until the appointment to a Glasgow Chair of Professor Lindsay[110] (later Master of Balliol) who felt how wrong it was to abstain from doing everything possible to further the cause of socialism.

One of the chief moves in the W.E.A.'s work for which I was responsible was the inauguration of a scheme of popular lectures on Saturday afternoons. I opened this with a group of four lectures on evolution. At the first lecture the room was packed and there were as many again outside. At the next committee meeting there were strong complaints and the very unfair criticism was made that the room was "crowded by wealthy women in furs". However, I promised to do what I could to secure better accommodation for the next lecture. All was well for we were given the Bute Hall, specially fitted with blackboard and project apparatus for the occasion. At the close of the first lecture I was asked if I would be willing to answer questions, to which I replied, by all means, but would it not be better to save up questions until the end of the course when I would be willing to give an extra Saturday afternoon for a 'heckling' meeting. This duly took place on January 16th in the large hall of the Technical College, which again was crammed. I had an entertaining couple of hours answering questions, some of them skilfully designed to entrap me in matters of religion and politics. One of the former I evaded by explaining that I would as soon think of kicking away the crutch of a cripple as of saying anything calculated to weaken anyone's religious faith. I think everyone enjoyed that heckling meeting and I could not help noticing the mountain of silver contributions which it brought to the W.E.A. funds.

Another set of popular lectures was arranged in response to an appeal from a London body emphasising the spread of public interest in the subject of sex and heredity, and the urgent need of popular information on these subjects that could be trusted as scientifically reliable. It was suggested that I might give a short course of public lectures to meet this need. I felt much sympathy with this appeal but suggested that the influence of such a course would be such increased by its being shared by Bower, Professor of Botany, and Dr W.E. Agar of my department. The idea materialised in the winter of 1917-19 in a set of six lectures: two by Bower on the vegetation kingdom, two by myself on the process of reproduction in the animal kingdom and two by Agar on the phenomena of heredity. The lectures attracted crowded and keenly interested audiences in one of the large halls of the city and a year later were published in the form of a small book[111].

A compliment which I much appreciated was being chosen to be President of the Zoology section at the 1926 Meeting of the British Association for the Advancement of Science , which promised to be of unusual importance in view of its place of meeting being Oxford and its President the Prince of Wales. I decided to break away from tradition in the matter of my presidential address. In place of the customary exposition of some particular section of Zoological Science, I decided to devote my address to a more general subject, the training of the citizen as viewed from a standpoint of the evolutionist. In primitive man, still exposed to the full pressure of the struggle for existence, a main part of his education consisted in the training of his powers of observation and in the power of quick and accurate interpretation of what he observed. His continued existence depended – apart from physical health and strength – upon these powers and on his constant mental alertness. With later evolutionary developments came printing, newspapers, the electrical telegraph, the cinema, facilitating the broadcast diffusion of ideas and tending to transfer leadership to the glib writer or talker – even though devoid of other and much more important qualifications. I urged the importance of infusing the ordinary school curriculum with a modicum of science, commencing with practical physics – unequalled as a means of training in accurate observation and proceeding to biology, more especially its general ideas rather than information regarding details. My Oxford address excited such interest and was widely reported in the world's press. I was greatly pleased by the general

accuracy of the reports. It was obvious that they were in great part based upon actual perusal of the printed text of the address.

At the British Medical Association's meeting in Glasgow in 1922, I was invited to deliver the popular lecture and chose as my title 'The Physician: Naturalist, Teacher, Benefactor'. Other addresses of general interest delivered to the Royal Philosophical Society of Glasgow dealt with 'Science and Education' (1919), 'Science, the new Philosophy' (1924), and 'Citizenship' (1926). The address on Science, the new Philosophy seemed to excite special interest from its emphasising the fact that the universe in which we exist is one of black darkness and absolute silence. The whole world of colour with its endless variety and beauty, whether in nature or in art, was a mere figment of our own mentality resting on the fact that we had a particular sense organ - the eye – capable of transforming periodic disturbances in the something-or-other, which used to be called the ether, into sensory impressions. And so also with the world of sound – the hum of insects, the songs of birds, music – again a figment of our own mentality resting on the fact that we had a special organ of hearing capable of transforming waves of compression of matter into sensory impressions.

In 1929 came an interesting invitation – to undertake a new adventure on the part of the B.B.C. in the form of a set of six lectures on zoology. These lectures entitled 'Links in the Chain of Life' were broadcast from Glasgow in January and February 1930. Broadcasting in those days was complicated by the absence of individual stations capable of nationwide transmission, which necessitated simultaneous broadcast from a number of different centres. It was a curious experience sitting in a dark room in Blythswood Square watching the appearance of lights indicating the linking up of the various centres until there came the final signal for me to start talking. It was also a strange experience in those days to lecture to an invisible audience especially for one like myself so accustomed to keep in touch with the audience with careful watch over their expressions. However, the shoals of appreciative letters I received indicated that my broadcast had been well worth while, and that the rather forbidding introduction to my audience as 'Professor Graham Kerr – The Worker' had not resulted in a universal switch-off!

In all these extra addresses and lectures I did my best to provide a worthy extension of my teaching beyond the ranks of my ordinary university students. An attractive feature of a teaching post in Natural History is that the extent and variety of the subject provides opportunity for interesting work during vacation periods. During my tenure of the Glasgow Professorship I made full use of this facility.

It is one of the interesting facts of Natural History that many animals, instead of passing through their early stages in the seclusion of an egg-shell or within the body of the mother, lead a free existence as larvae. These larval stages frequently live a quite different kind of life from the adult and in accordance with this they may be utterly unlike the parents in appearance and structure: for example, creatures that when adult lead a completely sedentary existence, such as many shellfish, swim about freely during their young stages. These larvae – often microscopic in size – with their endless variety and frequent beauty of form provide a fascinating subject of study.

Although much of the pioneering work upon such larval forms had been done at Cambridge, the ordinary student in that university was given little opportunity to see for himself the various types of larvae with which he had become familiar through lectures or textbooks. That omission I resolved to correct at Glasgow, which meant that I had to set about getting together as complete as possible a collection of typical larvae, preserved by the most perfect methods for study by students. Such larvae, usually microscopic in size, constitute the main part of the plankton or drifting fauna of the sea and my first step was to find a sea area not too far distant in which the conditions were as favourable as possible to the life of plankton. Inspection of charts of the west coast of Scotland disclosed an apparently ideal locality in Loch Sween – a sea loch opening off the Sound of Jura with its strong tidal currents, extending in a north-northeast direction for some miles, and dividing into a number of branches which, with their great variety of coast line and bottom, might be expected to harbour a most varied fauna. This expectation turned out to be fully justified and Loch Sween became the scene of many vacations' work (Figs. 13 and 14).

The unusually small volume of fresh water flowing into the loch permitted the salinity of its waters to remain remarkably constant. It was only after a heavy downpour of rain that a thin layer of lesser salinity could be detected over the surface of practically pure ocean water. The temperature of the water also remained remarkably constant, apart from the surface layer. The frequent changes in water level presented a puzzle, for I failed entirely to correlate them with the three obvious factors, the tidal level outside in the Sound of Jura, the prevailing wind, and the barometric pressure. I found myself forced to the conclusion the there must exist, in addition to changes due to these factors, a slow oscillation of the water from end to end of the loch similar to the "seiches" known to occur in many freshwater lakes – the narrow entrance to the loch with the strong tidal currents running past it caused the water to behave as if it were completely enclosed. The bottom of the loch was covered for the most part by very fine mud but the longest branch – Kyle Scotnish – was sufficiently narrow near its mouth to cause a strong current which prevented the deposition of mud at this point which as a consequence had its own and specially rich fauna.

Although the water of the loch was at all times clear, its precise degree of transparency did show considerable variations from time to time. Normally, the transparency or otherwise of sea or river water depends upon the amount of mud suspended in it, but here in

Fig. 13. View of Loch Sween, in the days when JGK frequently visited the area. (Photo: Department of Zoology Archives/University of Glasgow)

Fig. 14. JGK at Loch Sween, collecting specimens on the rocky shore. (Photo: Department of Zoology Archives/University of Glasgow)

Loch Sween the conditioning factor was quite otherwise, namely, the greater or less abundance of minute – microscopic – living organisms.

Each of the various environments in the loch had its own characteristic and luxuriant fauna: the muddy bottom with sea-pens (*Pennatula* and *Virgularia*)[112] and its own meadows of sea grass (*Zostera*) with their small purple sea-urchins and their creeping molluscs such as *Philine* and *Acera*, the latter at times to be seen flitting through the water like sea-butterflies: the rocky southeast bank of Kyle Scotnish with its great nudibranchs (*Doris* and *Facelina*) and sea-urchins (*Echinus esculentus*), those strange worms, *Chaetopterus* and *Phoronis*, and an occasional lobster. By far the most interesting part of the fauna to me, however, was the plankton, ranging from large jelly-fish a foot or more in diameter down through innumerable grades of microscopic organisms – some of them plantlike such as the diatoms which, during the hours of daylight, keep up a continuous supply of the oxygen required by their animal companions. Conspicuous members of the plankton were a wonderful variety of those larvae which, as already mentioned, were my special quest. It was a really astonishing spectacle when examining under the microscope the catch of the tow-net to see there, almost jostling one another, practically every one of the varied forms of larvae which I learned at Cambridge to be familiar with in lecture and textbook diagrams. It was fascinating sometimes to watch them under the binocular microscope, e.g. the larvae of the ordinary acorn-shell or barnacle which covered the rocks near high water mark everywhere. Its larvae were to be seen cruising about in the water until eventually, as the end of larval life approached, there developed a pair of glands at the front end which secreted a sticky cement. Now when the larva blundered against a solid surface it tended to stick: and when endeavouring to free itself, looking absurdly like a human being walking along adhesive mud. Soon, however, its efforts failed and it remained fixed, gradually to undergo the changes which converted it into the familiar barnacle.

The rich plankton of Loch Sween was of interest apart from its constituent members, for it is the plankton that provides the food on which a great variety of marine animals subsist. Herring and mackerel possess in their gill openings a special apparatus to strain off the plankton from the water as it passes through them. Whales have a different straining apparatus in the frayed out edges of the plates of whalebone that hang down from the roof of the mouth. The fat of the whale, the highly nutritious flesh of the herring, are alike derived from the plankton on which they feed. So also with shellfish such as mussels and oysters. In successive visits to Loch Sween I planted out mussels at various rocky points adjacent to favourite picnic sites and they flourished and multiplied, providing delicate fare for our picnic. As regards oysters, the once considerable oyster population evidenced by the plentiful dead shells, had practically died out except in the small arm of the loch known as Linnhe Mhurich, but in the early years of the century, one could still find an occasional large oyster in the main arm of the loch and these gave an apparent clue to the cause of the oyster population dying out, in the fact that they were partially buried in mud. I came to the conclusion that the increasing deposit of very fine mud in recent years, whatever its cause, had tended to smother the oysters. And in view of the richness of Loch Sween in plankton, I felt that the oyster population might be restored again by planting imported young oysters on supports above the mud level. Such considerations naturally directed my thoughts towards possible developments of plankton research of economic importance. Why should not, for example, the Marine Biological Station at Millport take as its main interest the study of the Clyde plankton in relation to the all-important herring fishery?

When, for example, a local herring fishery such as that of Loch Fyne fell upon evil days, might not that well be due to local poverty in plankton, the herring having betaken themselves to localities in which the plankton was abundant? And I hoped, too, that one day attention would be paid to the development of means by which special concentrations of plankton could be located and followed with a view to its extraction from the sea water to serve as food for man.

Apart from its marine fauna the Loch Sween

neighbourhood was a naturalist's paradise and I made fruitless attempts to have it made a nature reserve[113]. However, in later years something in this direction was done when the greater part of the region was taken over by the Forestry Commission. In addition to my long vacation sojourns I used in pre-war years to take a party of senior students to Loch Sween at Easter and sometimes at Christmas, and in the early summer I made an occasional short stay with some of my junior staff. In later years my pioneer work on the natural history of Loch Sween was greatly extended by others, more especially by J.A. Kitching[114] and by members of the staff of the Millport Marine Station.

Loch Sween was not only marvellous as a centre for scientific work: it was equally so for a summer holiday. Its sheltered waters provided ideal conditions in which my young family[115] could learn the management of boats. Oib peninsula with its dense wood, the Fairy Isles with their many creeks, the varied scenery of hill and dale, the shore of the Sound of Jura, provided an infinity of delightful sports for holiday picnics. As a purely holiday centre the only serious rival to Loch Sween was the island of Colonsay, one of the Inner Hebrides, an island which for its size possessed a variety –hill and dale, sea cliffs and sandy shores, sand dunes and peat bogs – unequalled by any of the other islands. There I spent many long vacation holidays, especially when my family were in their early 'teens'. To them it was the great period of the year, the one period when we were together. We had great times, moving off for the day regardless of weather, camping in some spot comparatively sheltered according to the direction of the wind, and making a fire of driftwood. The children learned the various dodges of out-of-door-life – how to make their fire in pouring rain, how to extract the best shelter among the heather on a bare hillside, how to time the boiling of an egg when no watch was available by using a pendulum made of a stone and a bit of string. Then there was always the fascinating natural history of the island; the searching for rare plants, the luxuriant flora of the peat bogs with their rich crimson parterres of the three species of sundew (*Drosera*)[116].

When our picnic spot happened to be at the south end of the island there was the particular delight of watching the seals which during the period of low water rested from their fishing activities on the rocks between Colonsay and Oronsay. Counting them one day, we found 130 visible from one spot. As the tide rose it was amusing to witness their apparently ancestral dislike of the rising waters, curving their head and hinder ends upwards into a crescent as if to delay getting completely wet until the very last moment. Then they would slither off the rock and depart for their fishing grounds. If we happened to be afloat in the boat during this period the seals would bob up and inspect us with a most comical expression.

In the evenings we commonly fished for saiths and lythe[117], trailing lines with fly or spoon bait, and at such times we were apt to be accompanied by two seals, one on each quarter, who found it a convenient method of doing their own fishing - to pick off the fish that we had hooked. Once or twice the seal itself got hooked which meant the loss of our cast. The grey seal was not so numerous as its smaller relative[118], but a pair were usually to be found at the east end of Oronsay. One time we watched an exciting struggle between the male and an enormous skate which he had grabbed by the root of its tail. The struggle lasted quite a long time, the skate beating the seal with its side fins, but eventually it was terminated by the seal cleverly shifting its grip to the under side of the body of the skate and tearing it open. The grey seal produced its young in the spring and they spent much of their early life lying on isolated rocks where the children enjoyed giving them a friendly caress.

One of our troubles during earlier years at Colonsay was the absence of a suitable small boat. Eventually I had to refuse to take our usual farm-house, Garvard, unless the farmer, Mr MacNeill, undertook to obtain a satisfactory boat. In due course came the announcement that he had been to Oban and secured a boat of the most admirable kind. So on arriving at Garvard the first thing I did was to accompany Mr MacNeill and one of his men to inspect the boat. Its appearance did not inspire confidence. However, we got it launched and proceeded to hoist the sail. There was a fair sailing breeze blowing, but we had hardly got under way when there was a sound of rending of timbers, the mast and sail came down and an open split in the timbers flooded the boat with water. Fortunately the depth was only two or three feet and we were able to wade ashore. So next morning I walked in to the post office and telegraphed to my colleague, Professor J.H. Teacher[119], an appeal to do his best to secure a good sailing dinghy and send it off to us by the Colonsay steamer. Before night-fall the reply came that he had secured a 'Kilcreggan Imp', a 12-ft. centreboard sailing dinghy which had misbehaved by capsizing with its owner, a local minister. She, the *Curlew*, proved a most excellent boat and served us well for several seasons until replaced by a new boat of the same design. Rather a shock came when I first navigated the *Curlew* out on the west side of the island. The sea was calm except for the normal big Atlantic swell and as I drifted quietly along I was suddenly startled by the appearance of a sharp pinnacle of rock, on to the summit of which the boat very nearly subsided. This experience taught me the lesson that the west side of the island was no place for a small boat unless navigated by one with thorough local knowledge. On the eastern side of the island, however, we made great use of the boat, fishing, pottering about and collecting the small animals of the plankton with a fine tow-net, but we found the plankton was poor indeed in comparison with that of Loch Sween. The outlook from Colonsay provided a marvellous panorama – to the westward the open Atlantic with, on a clear day, Dubh Artach lighthouse[120], sixteen miles to the north-west, then clockwise, Iona, Mull, the mountains of Morven and Glencoe, the mainland of Argyll, the islands of Jura and Islay. Especially towards sundown, one could see these beautiful soft colour effects, surely unsurpassed anywhere in the world - the pearly grey sea with the wonderful purple of the Jura

mountains. One evening, to complete the effect, the setting sun shining on a shower of rain between us and Jura added a perfect rainbow to the normal scheme of colour.

It was not at Colonsay but further north that my wife and I had the good fortune to see the 'green ray'[121]: not the slight green flush familiar to travellers at sea as the sun dips down below the horizon but the green ray which forms a centre for Highland legend. It was one evening in June 1933, when staying with Sir Hector Cameron[122] near Morar, that we were sitting on the terrace watching the brilliant setting sun about to disappear behind the Cuillins. There had just taken place one of the periodical correspondences in *The Times* in which the physicists explained it all simply in terms of refractions of light of different wavelengths, and I said to my wife, 'Now is the time to see the green ray'. As the last of the sun's disc disappeared behind the dark Cullins there appeared as it were a veritable explosion of the most intense emerald green – an experience never to be forgotten and sufficient to inspire any amount of legend. But now came the point of scientific importance. Just as the explosion occurred, my wife exclaimed: 'It moved as I moved my eyes'. It had happened that she was shifting her line of vision at the precise moment of the green flash, and the fact that the flash seemed to move with it demonstrated beyond question that the green ray as we saw it was no mere physical phenomenon but a subjective sensation. Our eyes had been flooded with the intense reddish yellow light of the sun and the sudden switching off of this caused the sensory impression to swing over to green, the opposite or complementary colour.

The natural history of Colonsay was very different from that of Loch Sween. The plankton was normally nothing like so rich, though on occasion one was made aware of the fact that a local concentration of plankton was slowly drifting past the island by the sea birds and porpoises feeding upon the fish which accompanied the plankton. Occasionally, too, especially after long continued south-west winds, there arrived visitors from distant warmer seas – including the sea snail *Janthina*, with its beautiful violet-coloured shell, and *Velella*, a relation of the Portuguese man o' war[123].

There was a great variety of birds, especially sea- birds. The predominant duck was naturally the eider – it used to be called the Colonsay-duck, and in August one would see many broods of these – sadly diminishing in size as the season went on – for there were many predatory black-backed gulls. On occasions skuas could be seen bullying other gulls and terns to disgorge their food and swooping down on it before it reached the water. On the sandy shores were flocks of little ring-necked plovers and dunlins – and the children were delighted to see the perfect camouflage of their eggs, and of the young chicks as they flattened themselves down upon the gravel as we approached. It was instructive, too, as these waders rose into the air and swung round in a curve to alight a little further along the shore, to observe how they vanished as they turned their white under surface towards us, telling us incidentally, as do all fish-eating birds, that white is the proper coloration, to diminish conspicuousness of war aeroplanes against a background of sky. Another lesson in camouflage was taught us by the turnstone as it picked its way among the rocks, its body rendered almost invisible by its 'dazzle' markings – a patchwork of violently contrasting pigments.

It was during one of our Colonsay sojourns that the First World war broke out. I had gone down to the port at Scalasaig to await a friend's yacht which was to pick me up, when a telegram arrived intimating that the cruise was off owing to the uncertainty of the situation, and presently news arrived of the outbreak of war. Colonsay was pleasantly remote from the major operations of the war, but there developed a good deal of submarine activity away to the westward – much infested by German submarines whose activities were betrayed to us by the sound of distant gunfire or the explosion of a torpedo or mine. Several mines drifted ashore on Colonsay and one or two exploded without doing any damage. One day towards the end of the war we had a fine view of a cruiser dashing past, close inshore on the eastern side of the island, clearly intent on business and I was glad to see she was camouflaged, in dazzle paint, though not very effectively, but as always she showed no sign of countershading[124].

A good deal of war debris was washed up on the western shores of Colonsay – a life raft, miscellaneous wreckage, and cargo materials such as crude rubber and barrels of oil. An exciseman travelling with me one time to Colonsay told how on a recent occasion when many barrels of oil came ashore, the islanders had been most helpful in handing over the barrels to the authorities, but what a shock they had received on learning later that amongst the barrels of oil they had unwittingly surrendered a barrel of good Scotch whisky.

Just at the outbreak of the war in 1914, I was puzzled by the behaviour of a large steam yacht distinctly visible through my binoculars and apparently anchored in the open close to the south-east tip of the island of Mull. Gales blew and high seas raged and she seemed to remain quite unperturbed at her strange anchorage. It was only a few weeks later when returning from Colonsay to Oban that I discovered the mysterious 'yacht' to be the hospital ship *Maine,* presented by the U.S. Government, which had run ashore on a rock near the entrance to Loch Buie and remained there immovably fixed.

Looking back over my long tenure of the Glasgow Professorship, I never fail to be impressed by my extraordinary good fortune. My main task, that of creating a modern Department of Zoology in place of the old Department of Natural History, so long controlled by Professors who were geologists rather than naturalists in the ordinary sense of the term, was one of fascinating interest. I was helped in my task throughout by that remarkable series of loyal and able helpers, and I had the further good fortune that the central twenty-

two years of my Professorship came in the academic reign of Principal Sir Donald MacAlister, unrivalled as a University administrator and always to be relied upon for sympathetic consideration of my difficulties.

The one cloud which overshadowed my early years in Glasgow arose out of a most unfortunate misunderstanding. In my interview with Lord Balfour, I had emphasized that to me one of the great attractions of the Glasgow Professorship was the prospect which it afforded of carrying on my earlier interest in the marine biology of the Clyde, and in my official letter of application I foreshadowed the hope that Glasgow, with its proximity to the Clyde 'and with the Marine Laboratory at Millport', might become one of the chief national centres of zoological research. Unfortunately, my strongest local rival for the Chair, Dr James F. Gemmill[125], was also pre-eminent among the supporters of the Millport Station at which he had carried out a long series of important pieces of original research. The mention of my own prospective interest in the Station was immediately pounced upon as indicating the intention on the part of the Cambridge invader of doing his best to annex the Millport Laboratory to his own department in the University. In point of fact, I was of the opinion that it was to the interest alike of the University department and of the Millport Station that their relations should be those of friendly alliance but completely independent. If brought into the University organisation the Station would be in competition with other University departments for already inadequate financial resources. However, it needed the passage of many years and the advent of a dominant new factor before the evil working of this misunderstanding came to an end.

The origin of the Millport Marine Station had been due to Sir John Murray of the Challenger Expedition who, in connection with certain researches supplementary to those of that Expedition, had brought round to the Clyde his floating barge laboratory, *The Ark*. After the completion of his work, he decided that *The Ark* should remain on the Clyde as a centre for marine biological research, and with this end in view he placed her at the disposal of a committee of persons interested in natural history, headed by David Robertson[126] – a Glasgow business man and enthusiastic amateur naturalist who had made important contributions to our knowledge of the marine fauna of the Clyde. *The Ark* was wrecked by a gale in 1900 but she had proved so attractive both to researchers and to casual visitors that the committee had already decided that the good work must by expanded by erecting a permanent laboratory building ashore. Funds were collected, a site was provided by the Marquess of Bute[127], and the new Marine Station was opened by Sir John Murray in 1897. Unfortunately, divergences of opinion soon began to show themselves in the governing body as to what should be regarded as the main objective of the Station, one section – including most of the University representatives - placing the furtherance of biological research first in order of importance, the other giving priority to educational activities – formal through vacation classes to teachers in training, informal, by encouraging visitors to the aquarium and museum collections.

At the time of my appointment in 1902, this division of opinion was already marked by somewhat violent personal feelings, which I as a newcomer naturally wanted to see die down. The unfortunate misunderstanding already alluded to served, however, merely to exacerbate them and they reached a head when the Annual Meeting of subscribers in 1907 passed a resolution forbidding the staff to carry on with the admirable work on which they were engaged – a 'Biological Survey of the Clyde Sea Area'[128]. This complete *volte face* from the intentions of John Murray when he initiated the research centre at Millport led to the resignation of the chief officers of the Association together with the majority of its biological members, and a little later the scientific superintendent of the Station.

The upheaval at Millport involved severe interference with the practical facilities available to the University Department of Zoology but this was mitigated by the sympathy and generosity of the Marquess of Bute who purchased the aquarium building at Rothesay[129], fitted it out as a laboratory, and placed a properly qualified biologist in charge. During the next few years the Rothesay laboratory under its successive heads provided the centre at which the Glasgow students gained their practical experience of Marine Zoology. It was so successful that Lord Bute planned to erect and endow a fine new Marine Station within his own grounds at Mount Stewart, but his plan was brought to an abrupt end by the shock he received as a witness before the Sankey Commission[130] which seemed to imperil his whole financial future. While reluctantly abandoning his plans of a Mount Stewart marine station, Lord Bute agreed to my suggested foundation of a 'Bute Marine Biological Committee', with himself as Chairman and a purely *ex officio* membership, to receive and hold sums of money for the furtherance of marine biological study in the Clyde region. Safeguarded by its constitution against interference by personal animosities, this new committee might be trusted to wield a good influence for the future. In point of fact it did so until at long last the Millport Station was brought back into harmony with the aim of its founder. The first promise of this came through Sir John Murray himself. We frequently dined together as members of the Royal Society of Edinburgh Dining Club and I did not conceal from him my view that the only hope for the Station lay in the possibility of his taking it over. Eventually on 13th February, 1914, he took me to see his friend, Mr Laurence Pullar[131], who had shared financial responsibility with him in connexion with the survey of Scottish lakes. It was agreed that they should proceed together to Millport to make a preliminary inspection before entering on negotiations for taking over the Station. Alas! on 10th March, a week before the proposed date of their visit, Murray's life was brought to an end by a motor crash.

The actual dawn of brighter times for the Station came after the end of the war when my old friend and yachting skipper, W.B. Hardy, got me included in the personnel

of the committee appointed under his Chairmanship 'to advise the Development Commissioners on the character and scope of the research required for the development and improvement of the fisheries of the United Kingdom'. A special sub-committee under the Chairman and including myself was appointed to consider the question of grants in aid to research institutions, and this sub-committee at once proceeded to get into touch with the Millport authorities. After full enquiry they expressed their desire to see there 'a biological station staffed and equipped to deal adequately with areas of such great interest to the zoologist and to fisheries as are the Clyde area and the sea off the west coast of Scotland', and their willingness to recommend a grant in aid sufficient to make possible the development of such a Station. The essential condition that the affairs of the Millport Station should be put under the control of a strong executive committee working in harmony with the scientific staffs of Glasgow and the other Scottish universities was at once agreed to, and grants were recommended to recondition the Station and its equipment, to provide two research vessels, one of the fishing boat type, the other in the form of a motor barge capable of working in the fjord-like sea lochs such as Loch Sween, and to appoint a scientific staff. The Station would require the appointment as Director of 'a Scientific man fully trained and with a high capacity for research', but this would have to wait. In the meantime two Glasgow University graduates were appointed, Miss Sheina Marshall[132] as naturalist and Mr A.P. Orr[133] as biochemist. It need only be added that in succeeding years, with the continued interest of the Fishery Research Committee under its successive chairmen, Sir W.B. Hardy, Professor E.W. MacBride[134] and myself, the Millport Station continued to flourish and to justify itself by its important contributions to the advancement of marine biology[135]. At the same time, its relations with my department in the University remained friendly and to the mutual advantage of both. And what remained of personal feeling among members of the staff was driven underground and deprived of serious effect.

Apart from the Millport complication, my personal relations throughout my Glasgow period were without a cloud. Academic society – devoid of the College life of Cambridge – was, of course, very different, but the existence of the Professors' Square with its 13 houses allocated to the Principal and 12 Senior Chairs ensured a nucleus of almost family intimacy. Although the Chair of Natural History was not one of these, I was fortunately able to rent the house which had been inhabited by the late Professor of Medicine, his successor preferring to retain his more centrally placed residence in the city.

A matter of great significance to myself and my department was the appointment as Principal in 1907 of Donald MacAlister whose quite outstanding ability I had learned to appreciate at Cambridge. His principalship lasted until 1929 and throughout that long period he never failed in his understanding, sympathy and helpfulness towards my efforts in developing my department. He was too strong a man to be universally popular but he certainly earned an incalculable debt of gratitude from the University of Glasgow. Perhaps his greatest service was his bringing together into co-operative friendship with the University, the City and the important extra-mural educational bodies, the Royal Technical College and the Medical School of the Royal Infirmary. More impressive, perhaps, to the general public, were the remarkable tributes he received from wealthy citizens of Glasgow in the form of endowments for new Professorships in the University. Of the 57 Chairs of the University at the time of my retiral in 1935 no less than 22 dated from Principal MacAlister's period of office. My own appointment came just after the revolution in University administration brought about by the Universities (Scotland) Act of 1889 and the Ordinances of the Commissioners appointed under that Act. Up to that date the *Senatus academicus* – the body of Professors – had been the supreme governing body of the University. The individual Professor was practically an autocrat in his own department and his remuneration consisted of the fees paid by the students. This arrangement involved as natural consequences on the one hand the high development of lecture technique and its capacity for attracting students, but on the other hand discouragement of expensive practical and laboratory activities which had to be paid for out of the Professor's own pocket. In placing the remuneration of the Professors on a fixed salary basis and freeing them from the payment of salaries of assistants and expenditure on laboratory equipment, the 1889 Act freed the Scottish Universities from what had been a fatal obstacle to their advance as centres of scientific teaching and research.

The strongly marked individuality among the Professors encouraged by the pre-1889 conditions had by no means disappeared during my early years in Glasgow. Amongst the Professors there were several real 'characters'. John Ferguson[136], Professor of Chemistry, though little interested in modern developments of his science, was one of the greatest authorities on alchemy. He had a long beard and the tale was told how at a University dance his partner in a waltz felt her back hair coming down and pinned it up, only to find at the end of the dance that she had pinned up her partner's beard. He was our most knowledgeable Professor in the matter of food and drink and used to give admirable little dinner parties. Walking back with F.O. Bower from the last of these, I remarked to Bower that I thought Ferguson in particularly good form. Bower did not agree: had I not noticed a most serious symptom – that he had begun to pour one of the wines into the wrong glass? And sure enough he was dead within a week. Poor Ferguson was given a dreadful time by his students who made his lecture- room a regular pandemonium. His lecture at 10 a.m. came between my lecture at 9 and my practical class at 11 and every now and then I would see his students streaming along towards my department at half time, having deserted his lecture-room *en masse.*

Another great character was James Moir[137], Professor of Conveyancing, who had the reputation of never having been known to speak well of anyone. I was glad to be

able to vouch for having myself heard him speak well of someone - Sir Thomas McCall Anderson[138], who had just died.'Well! They may say what they like about Tom Anderson but more than once I have known him to say or do a thing that I could not see what advantage it would be to him'. That, however, appeared to be the summit of his appreciation of anyone. I remember being startled at a Senate meeting when on someone proposing the Reverend Professor James Cooper[139] as our representative at the General Assembly of the Church of Scotland, Moir rose to his full height and commented, 'A most improper person', though it could never have occurred to any other member of the Senate to think of Cooper otherwise than as the very soul of propriety.

My most intimate friend among my fellow Professors was Frederick Orpen Bower, Professor of Botany. He did not give himself airs and I often felt that Glasgow did not always realize the fact that Bower was one of the greatest botanists of his time. To myself he was the most loyal and helpful of colleagues. A colleague whom I saw a good deal of was William Macewen[140], Regius Professor of Surgery and the greatest of Lister's successors in the Glasgow school. Tall and with a well trimmed beard, he was a distinguished looking figure, especially when in court dress as a member of the King's household. Macewen had a habit of coming into my demonstrations to the elementary class. Two incidents stand out in my memory. The first was when he examined one of the early Levaditi[141] preparations of the spirochaete of syphilis and expressed his entire disbelief in its being the cause of that disease. The other was one day during the First World War when I noticed a man in naval uniform sitting down at one of the microscopes and studying the preparation under it. I did not look at him or his uniform particularly and took him to be some merchant skipper who had wandered into the department. However, after a bit I went to speak to him. He looked up and then I recognised Macewen disguised by the absence of his beard and his Rear-Admiral's uniform.

The hard work of early years in Glasgow was lightened by the charming hospitality accorded to my wife and myself by the residents in the west end of Glasgow. The dinners of those days had many guests and many courses, and the leaders of Glasgow business and professional life laid themselves out to do their very best to entertain their university guests. If the level of the talk was not quite up to that of Cambridge high tables, it showed on the other hand as mere conversation a much wider knowledge and much greater appreciation of the importance of public affairs. The great private dinner parties of those early years came to an end with the First World War. Thereafter, lunching and dining arrangements were mainly of a public nature. I was a frequent guest at the Lord Provost's weekly luncheon, and at big public dinners I was often called upon to propose the toast of the evening. I remember, one speech which went down particularly well when, in proposing the Corporation, I spoke of Glasgow as the Secret City – differing from St Petersburg, the Secret City of Hugh Walpole's book[142], in that Glasgow's secret activities were those of its trade incorporations and family associations which distributed their funds in secret help to those in trouble.

As a rule, my laboratory work extended over Saturday and Sunday, but there came an occasional week-end with friends in the country. Outstanding among these were week-ends at Ardgowan with Sir Hugh and Lady Alice Shaw-Stewart[143] and at Lochside with Mr & Mrs A.E.C. Clapperton[144]. In addition Alan Clapperton, then Secretary of the University Court, was a sympathetic listener and could be depended upon for friendly advice when occasional difficulties arose. Most important of all my personal relationships were of course those with my students. With them there was never a breath of discord. It was an understood thing that we all – students, Professors and junior staff – worked at high pressure during class hours. From my class room in pre-war years there emanated a deafening roar of community singing which ceased as if cut off by a switch when I entered the room at 9.03 a.m. and was succeeded by absolute silence during the fifty minutes of lecture. It was to me a personal delight – which lasted throughout my thirty-three years – to lecture to Glasgow students with their concentrated attention, their mental alertness and their sense of humour.

During the peaceful first decade of the century there still lingered in my mind the signs I had learned to appreciate in Jena 1894 and Kiel 1895 of a coming attack by Germany, so I was particularly interested when the scheme of an Officer's Training Corps in the universities of the country was inaugurated in 1909. I became a member of the Military Education Committee – a body composed of members of Senate together with the Commanding Officers of local units of the Territorial Army, which was to be responsible for setting up and supervising our unit of the O.T.C. Owing to the serious illness and prolonged convalescence of the chairman of the committee, D.J. Medley[145], Professor of Modern History, I had to act as chairman for the first year and a half. This meant a lot of hard work as, while purely military details were attended to by the excellent adjutant, Captain A.N.E. Browne, H.L.I., I was responsible for the business arrangements. These included clothing the unit, complicated by the fact that we had no money in hand. However, I assumed that the army contractors who provided uniforms adjusted their estimates in the knowledge of the precise dates on which the government grants would be available, and so remained unmoved by their fervent appeals for immediate payment of their bills. When my accounts for the first year were made up, I was worried by a discrepancy of a few shillings between credit and debit and it was only after many hours' work that I was able to trace down the discrepancy to the orderly room clerk having included an item in a petty cash total as well as putting it down separately. After the accounts had been sent in, there ensued a considerable correspondence with the auditor, closing abruptly with a letter from me:

Sir,
In response to your enquiry of date .... As

to whether item X is or is not included in the
total under heading Y, I have the honour to inform
you that item X amounting to £50 odd is not included
under the total Y amounting to £4 odd.
I have the honour to be,
Sir,
Your obedient servant

Soon after I happened to meet Lord Haldane[146], who was Secretary of State for War at this time, and he much enjoyed my tale.

In view of the restrictions on expenditure of government money to definite authorised headings I felt it was desirable to have a private fund for expenses that were expedient though not admissible under the authorised headings and a number of friends were good enough to become annual subscribers to this. The O.T.C. was a great success, and a gratifying experience was to notice its educational effect, apart from its training in military technique – the discipline, quick and accurate reaction to the word of command, and the general alertness instilled on the parade ground bringing with them corresponding changes in mental activity.

The Department of Zoology received the full shock of the actual outbreak of war in August 1914. All members of the staff – teaching and technical – who were of military age departed on war service, as did also a large proportion of the students. This involved the recruitment of temporary members of the staff to take the place of those who had left. It involved also a large increase in the number of women students, and following on this the infusion of women members into the teaching staff. As a teacher of medical students, I had to remain at my University post and my war activities were restricted to the selection of candidates for commissions, to my – in great part fruitless – efforts to get war camouflage put on a proper scientific footing, and to joining the local volunteers. The volunteers in their early months were without uniform and their only distinguishing mark was a brassard with the red letters G.R. signifying Georgius Rex. Not unnaturally they came to be known flippantly as the Gorgeous Wrecks. Their evenings were devoted to elementary military training, and their Saturday afternoons to route marches. I got my First Class certificate as instructor in musketry and became quite keen on that line of work. In my squad I had a skilled engineer and got him to prepare a greatly enlarged wooden model of the breech mechanism of the P14 rifle which was served out to the corps. This model was most helpful as an aid to musketry instruction.

During the later years of the war, I was one of those detailed for night duty at the docks – often of interest owing to the danger of spying activities by the crews of foreign vessels. Occasionally, when dealing with Spanish-speaking seamen who threatened to give trouble, I found that scraps of opprobrious language learned in South America were peculiarly effective. An interesting experience when I was in command of the guard at Meadowbank was the arrival of the Russian cruiser Askold with her five funnels which some years earlier had proved of so great psychological value in raising the prestige of Russia and lowering that of Britain in the Persian Gulf. At this period the crew had already seized control of the ship, though the officers were still alive and allowed to move about in apparent freedom.

Another interesting experience was when I noticed a ship, the figures on which indicated that her draught was much greater than what I knew to be the depth of the water at that particular spot. Further scrutiny disclosed other misleading features about her and she became clearly one of the notorious 'Q-boats', ordinary merchant ships disguised so as to entice hostile submarines within reach of their guns. At an earlier period in the war, other merchant ships in the docks had been conspicuous from their strange tripod masts intended to give them when seen in distant view the appearance of formidable battle cruisers. By far the most interesting, however, to myself personally was the arrival of ships camouflaged by paint, as I had been responsible for the initiation of that form of camouflage by my memorandum circulated to the Fleet in November 1914. I will defer saying anything more on this depressing topic until I come to the Second World War.

My period in the volunteers came to an end when – in order that I might take a more direct part in the Officers' Training Corps during the difficult period at the end of the war – I was given a junior commission in the Territorial Army (unattached). In December 1918 I was put through a course with the Grenadiers at Chelsea Barracks – somewhat trying as the course was arranged for serving officers back from various fronts and accordingly adapted to the capacity of younger men with active service experience.

Apart from my teaching work and the administration of my large department, I did my best to avoid unnecessary outside entanglements. However, there were many which were unavoidable. Amongst these were the continuing responsibilities of the Faculties of Science and Medicine, of each of which I was an *ex officio* member. Then I had eight years' membership of the University Court including the period of the First World War, with its innumerable problems of detail such as the presence of persons of German blood or sympathies on the teaching body, the question of insuring or not insuring the University against possible damage by enemy action and so on.

During the later years of my Professorship came other interesting responsibilities following on my election to the Board of Management of three important Glasgow institutions - the Royal Infirmary, the Royal Technical College and the Anderson College. Of these, the first was of particular interest – for it was in the Royal Infirmary of Glasgow that Joseph Lister[147] – at that time Professor in the University – laid the foundation of modern surgery. I was brought into immediate contact with the Infirmary's activities by being a member not merely of its governing body but also of its medical committee. Work at the Technical College, with its very

highly qualified teaching staff and the large body of students attending its evening classes after their day's work in factory or shipyard, was again of absorbing interest and I occupied latterly the position of Convener of the committee controlling training and navigation. The Anderson College of those days was the main extra-mural school of medicine and my position as Governor brought many interesting problems bearing upon both its own teaching activities and their relation to those of the University.

Holding as I did the King's Commission as Regius Professor, I preferred to abstain from taking any active part in party politics. That did not mean that I was without party sympathies. I naturally agreed that our country's prosperity was ultimately dependent upon labour but it seemed to me preposterous that the word labour should be used by politicians as if it did not include brain labour – as expressed in invention, administration and management – as well as manual labour, and it appeared to me ridiculous not to admit the overwhelming importance of the former. The excellent handiwork of that one time employee of the University of Glasgow, James Watt[148], was surely of quite insignificant importance in comparison with his bit of brain work which invented the idea of separating the condenser from the cylinder, thus making the steam engine an economically practicable instrument – and incidentally providing the impetus for the Industrial Revolution. And it seemed to me beyond question that the one of the two dominant political parties which had the surest grasp of the needs and claims of labour in the broader sense was that which went under the name Tory, the more modern Conservative, or the less misleading Unionist.

My resolve to keep apart from open participation in party activities persisted until January 1924 with its announcement that Mr Ramsay MacDonald[149], head of the Labour Party, was now Prime Minister. This news was to me so alarming that I at once got into touch with the Secretary of the Hillhead Unionist Association and asked him to enrol me as a member. I duly attended meetings, did my duty as member of the Executive Committee and was chosen as a representative on the General Committee of the Glasgow Unionist Association – comprising the local Unionist Associations of the fifteen parliamentary divisions of Glasgow. A few months later – in November – there happened an incident which was to influence my whole subsequent career. I was rung up by Sir Archibald Craig, one of the leaders of Unionist politics in Glasgow, who said he had been authorised to ask me a question to which he hoped I would not answer 'No' without careful consideration. The question was would I allow my name to be proposed for the Vice-Chairmanship of the Glasgow Association. My answer was that if the suggestion was really serious – which I ventured to doubt – I did not see how I could possibly refuse. My nomination followed in due course, and on 31st January 1925, I was formally elected.

Owing to the ill-health of the Chairman, Sir Archibald Craig, I found myself almost immediately entangled in the task of presiding over meetings of the General Committee. At first there was a little trouble. It seemed, no doubt, strange that a comparative outsider should have been chosen instead of one of the many members who had years of experience in handling the Association's affairs. However, matters soon settled down and there ensued five years of absorbing interest, two as Vice-Chairman and three – after the death of Sir Archibald Craig – as Chairman. I was fairly successful in discharging the duties of these posts but I have never failed to attribute my success in great part to the fact that I had by my side that marvellously efficient Secretary, Lewis (later Sir Lewis) Shedden[151]. Beginning as office-boy, Shedden had spent his whole working life in the service of the Association. He knew everyone and was equally at home conversing with a Duchess or a 'shawl lady'. He had a remarkable memory and it was a treat to drive round with him to meetings of the Divisional Associations and listen to his continuous ripple of recollections associated with the various streets and those who in time gone by had dwelt therein.

It was my custom on the afternoon before each committee meeting to go down to the office and go carefully over the details of the agenda and consider as to whom I should invite to speak on each item. The result of this careful preparation was that the business of the meeting went through so smoothly and expeditiously as to win the approval of those present, apart from the small minority who always felt aggrieved by their so obviously pre-eminent claims to take part in debate being passed over. Apart from the ordinary business meetings there was not during the greater part of the year much for the Chairman to do. In January, however, there were held the Annual Meetings of the Divisional Associations, and at these the Chairman of the Glasgow Association was expected to put in an appearance and 'say a few words'. Then followed the Annual Meeting of the Glasgow Association when office bearers for the year were elected and speeches upon the political situation were delivered by some of the Unionist representatives of Glasgow constituencies in Parliament. Now and then some emergency claimed the attention of the Chairman. A vacancy in the parliamentary representation of one of the Divisions brought the responsible task of joining with the divisional committee in its consideration of whom to adopt as the official candidate, and, after this had been settled, of being present at his first meeting with the constituents: as well as, of course, working behind the scenes of his success. On at least on one occasion I found myself in the unpleasant position of having to agree to the withdrawal of official support from a candidate for whom I had a high personal regard but who was unwilling to abstain from the public expression of views conflicting with official statements of party policy.

To myself, accustomed in my scientific career to express my own opinions, however much they conflicted with those of authority, it was peculiarly difficult to speak and act in support of party policy when in conflict with my own personal views. However, I realised that the

working of parliamentary democracy would be quite impossible without the subordination of personal opinions to those decided on by the leaders of the party. Particularly delicate were my duties in cases when discord had broken out among the members of some particular Divisional Association. Complaints would come in as to the deplorable behaviour of a certain section of the members and an appeal would be made to the chairman to put matters right. The Secretary would write and say that I would be glad to hear all about the trouble if they would come to the office at 2 p.m. on a particular day. At 2 p.m. I would be in the Chair and one of the two parties would be ushered in and would take their seats. Then the other party would be brought in and would take their seats, the two lots interchanging glances of the most unfriendly kind. Then, after greeting the company and expressing my regret at hearing of their troubles, I would call upon them in turn to explain to me what was wrong. There would follow prolonged and eloquent denunciation of the enormity of the conduct of those on the other side. On one such occasion it was 6 p.m. before all the steam had been blown off and the pressure down to zero. Then, after expressing my thanks for their patience in giving me such a detailed exposition of their woes and my sympathy with them in their troubles, I would indicate the need of time for careful consideration of their difficulties. And so the company would disperse, the violent feelings of 2 p.m. entirely dissipated and nothing more would be heard of the matter.

After being twice re-elected, my term of office as Chairman of the Glasgow Unionists reached its three-year limit and I looked forward to the end of my political interlude. On February lst 1931 I attended my last Annual Meeting as Chairman of the Glasgow Association and it was pleasant to be once again free to give my whole energies to scientific work. My respite from politics turned out, however, to be merely temporary. Towards the end of October 1932 I had a call from Sir Henry Mechan[151] who said he had been deputed by the Western Divisional Council to express its desire that I should become its Convener – this office bearing a relation to the constituencies of the West of Scotland similar to that which I had already held as Chairman to the fifteen constituencies of Glasgow.

I was duly elected Convener for the year 1933 and re-elected for the following year. My period as Convener was again of great interest and I had again by my side the inimitable Lewis Shedden as Secretary. On 23rd November 1934 I was elected President of the Scottish Unionist Association. The duties of this office, tenable for one year, were relatively light, the detailed business of the Association being carried on by the Eastern and Western Divisional councils.

On occasion there would be a meeting of the Central Council, composed of the two Divisional Councils, and then the President of the Association occupied the Chair. During my year of office the most important meeting of this kind took place to consider the Scottish Housing Bill which brought out strong divergences in opinion between east and west in regard to the Scottish system of Rating. I had to do my best to keep my attitude strictly impartial. An entertaining experience was the delivery during the meeting of no less than 470 telegrams addressed to me personally, urging one side of the case – which I remarked might be interpreted either as showing an overwhelming mass of opinion on that particular side or on the other hand the excellent organisation of its supporters.

On Friday 29th November, I had to preside at the Annual Conference of Scottish Unionists at Dundee. There were present between two and three hundred delegates, and morning and afternoon sittings were devoted to discussion of various Scottish interests, more especially agriculture. This involved several speeches: one moving the adoption of the Annual Report, a second proposing a resolution expressing satisfaction at the Party's victory in the General Election, congratulating Mr Baldwin[152] the Party's leader, and pledging support to the National Government, and a third introducing Mr Baldwin to the great evening meeting of over 3,000 – in the Caird Hall. Apart from these speeches, the day's work involved constant supervision of the general business of the conference. The evening meeting was a great success. In view of threats of serious trouble by the local 'Reds', a force of two hundred stewards was scattered through the hall but there was no trouble whatsoever, only the greatest enthusiasm.

These were the days of university representation in Parliament[153], when it was generally felt that the House of Commons was strengthened by the infusion of a few members whose knowledge and university experience gave weight to their opinions on matters of public importance, but who could not be expected to subject themselves to the rough-and –tumble of an ordinary election.

Within the University of Glasgow, the interests of Unionism had been kept alive over a long series of years by the devoted exertions of a single individual, T.A. Harvie Anderson[154] of Quarter – a prominent Glasgow lawyer who was also well known for his activities as Secretary of the Glasgow Territorial Association. Right up to 1950, when university representation was brought to an end by the Labour Government of the day, Mr Harvie Anderson continued to devote himself to the cause of Unionism in the University of Glasgow and indeed in all the four Scottish universities. Mr Harvie Anderson had been accustomed to summon more or less informal meetings of University Unionists as the occasion arose, but in the winter of 1928-29 the Glasgow University Unionist Association was formally constituted. During the informal period the position of Chairman had been occupied by Sir Hector Cameron[122], Professor of Clinical Surgery, and as his health began to fail, I had acted as his understudy.

At the Annual Meeting of the Glasgow University Unionist Association on 4th February 1931, I was elected Chairman and *ex officio* one of the four representatives on the 'Standing Joint Committee of the

four Scottish Universities'. During my period as Chairman of the Glasgow Unionist Association the question was raised of my becoming a University candidate for Parliament, but I had had no difficulty in repelling any such suggestion. On the one hand, I was very happy in the work of running my University department and on the other hand I failed to see any attraction in subsiding at my age into the back benches of the House of Commons, but in 1934 my first wife died after a long illness, and I was brought to reconsider the possibility of Parliamentary candidature.

Westminster, 1935 – 1950

In 1935 came the elevation of one of the Scottish University members, Mr John Buchan[155], to the House of Lords as Lord Tweedsmuir, and I was at once pressed to consider the question of becoming a candidate in his place. It was pointed out that there was no one in the House of Commons with my experience of university teaching and administration. It was also stressed that in spite of the enormous part played by science in ministering to the health, comfort, and prosperity of our people there was in the House of Commons not a single Fellow of the Royal Society apart from those elected under a special statute, not for eminence in science but for their position as persons capable of furthering the general interests of science. I was assured that, if I were in Parliament, I should find myself being made full use of on committees dealing with matters involving science. I found myself confronted with a difficult problem, involving many factors. There was my university department, the development of which had been my absorbing interest over a period of thirty-three years. There was that wonderful staff of junior colleagues who had played such an all-important part in maintaining its efficiency. To step off into a new parliamentary life would mean severing associations that were very dear to me. And it was the case that my university teaching still constituted my keenest personal interest and also that the perfect silence and discipline in my lecture room seemed to show that I was still able to hold the interest of my students.

Again, there was the financial aspect. I was not a man of independent means and I had to face the fact that my election to Parliament would mean heavy financial sacrifice. There was no age limit to my university Professorship with its salary, at that time £1450[156], supplemented usually by one or more external examinerships. These emoluments I would have to exchange for a pension of £800, plus a Parliamentary salary, at that time £400, of quite uncertain tenure, and I should also be saddled with the expenses entailed by the fact of my parliamentary work being in London. However, after full consideration, I decided to take the plunge. The election campaign of a university candidate was a much less formidable affair than that of an ordinary candidate. There were no open public meetings, only a meeting with members of one's own party in each university centre. The main thing was the preparation of an election address and its circulation among the Scottish university constituents. This latter proved a formidable task as a large proportion of university graduates had not troubled to keep the university register up-to-date in the matter of their postal address.

In view of the near approach of a General Election it was expected by many that my candidature in a by-election would be unopposed. However, the Labour Party decided otherwise, and various possible Labour candidates were mentioned – among them my one-time student, A.J.Cronin[157] for whose literary skills I had great regard. Happily, however, he declined to stand and the Labour candidate actually nominated was Mrs Naomi Mitchison[158], daughter of my old friend Professor John Haldane of Oxford, sister of J.B.S. Haldane – a distinguished biologist, and herself possessing a goodly share of the heritage of mental ability enjoyed by the Haldane family.

The poll in a university election was carried out by voting papers circulated by post, each bearing the names of the candidates in alphabetical order, with spaces in which to indicate by a X to which candidate the vote was given, space for the signature of the voter, and space for the signature of a witness to the authenticity of the voter's signature. The poll extended over five days. Each day voting papers were counted by the Registrar of the particular university, under the watchful scrutiny of a representative of each of the candidates, who examined each voting paper in favour of the opposing candidate on the lookout for anything that might render the vote invalid. In spite of the simplicity of the voting paper and in spite of the voters being persons with a university education, there were no less than 652 spoilt papers! However, the declaration of the total poll – by the Vice-Chancellor of Edinburgh University – was eminently satisfactory, for out of the total votes recorded I had 20,507, while my Labour opponent had only 4,293, giving me a majority of 16,214 – a record majority in the history of Scottish University elections.

I took the first available train to London and on the way had an amusing adventure. At Newcastle there came into my compartment an elderly gentleman who was greeted by the only other occupant as a former colleague in the House of Commons. The two entered into conversation and the main topic consisted of speculation as to the probable result of the Scottish universities by-election. Naturally I intervened and informed them as to what had happened. Thereupon the three of us conversed and there came up the subject of the former Principal of the University of Glasgow, Sir Donald MacAlister, and his extraordinary linguistic ability. I capped the statements of the others by recalling an old yarn I had heard about a meeting of university Principals at which Sir Donald was present and at which an apology for absence was intimated from Principal Viriamu Jones[159] of Cardiff. "What an extraordinary Christian name, if you can call it Christian", remarked one of the assemblage. "Oh! I can tell you about that", said Sir Donald, "Viriamu, of course, is Fijian for William". "How very remarkable that you should tell me that story", said the elderly gentleman (who turned to be Lord Rhayader, formerly Mr Leif Jones[160]). "It's perfectly true! Viriamu Jones

was my brother and he was called after a missionary in Fiji named William whom our father greatly admired but whose name the native Fijians found impossible to pronounce except in the modified form Viriamu".

My introduction to the House of Commons took place next day – 26th June – and as I was the one new member the introduction took place with full ceremonial. Sir Lewis Shedden had come south for the occasion so I gave him lunch at the Athenaeum and we then proceeded to the House. I was shown into the Whips' room where everyone was extremely kind, and one of the Whips coached me up in the details of the ceremonial. I was then taken to a seat under the Gallery, i.e. below the Bar and outside the floor of the House, where I sat and listened to the answers to questions and received greetings from various friends. As questions approached their end I was lined up at the Bar with my two sponsors – on my right Captain Margesson, the Chief Whip[161], and on my left Noel Skelton[162], my colleague in the Scottish universities representation. After the last answer had been given, Mr Speaker stood up and invited Members desiring to take their seats to do so. The Chief Whip growled 'Bow' and we all three bowed, then stepped off, left foot first, took five paces forward and halted. Then again 'Bow' and we bowed simultaneously and again stepped off, left foot first, five paces forward, which brought us up to the table of the House. Here we halted, bowed simultaneously for the third time and then my sponsors slipped away and left me alone at the table. The Clerk of the House – the senior of the three bewigged figures seated at the table in front of the Speaker – rose from his place and demanded from me the blue paper certificate of my election signed by the Clerk of the Crown. Having satisfied himself about this, he deposited the certificate in the box on the table and handed me a testament and a board carrying the words of the Oath of Allegiance. These I duly recited and kissed the book. The Clerk conducted me forward to sign the test roll and then to the Speaker who shook me by the hand. My introduction complete, I retired from the Chamber behind the Speaker's chair and I was delighted to receive my first congratulations from my one-time student, Walter Elliot[163], now Minister of Agriculture and Fisheries.

As luck would have it, a division took place immediately after my admission, so I was introduced to our primitive method of taking a vote by counting members as they passed through the 'Aye' or the 'No' division lobby respectively, which has the advantage of separating the two bodies of – it may be – violently opposed opinion and giving a few minutes for feelings to cool down. After the division I was taken in charge by the Lord Advocate, Douglas Jamieson[164], who showed me round the complicated topography of the House. In the cloakroom I was shown my hat peg, still bearing a loop of tape for the reception of the Member's sword – reminiscent of the day when the sword was an article of ordinary attire but had to be left behind before entering the chamber. Then to the fees office where I was given my book of railway vouchers, with the smiling advice that whereas the ordinary M.P.'s voucher was valid only between London and the chief town in his constituency I, as a Scottish university Member, could travel as I liked between London, Edinburgh, St. Andrews, Aberdeen and Glasgow!

Throughout the afternoon I was constantly receiving greetings of welcome. Ramsay MacDonald was particularly cordial. Neither he nor his son had a vote in the Scottish university constituencies but his son-in-law and daughter had voted for me. Sir John Simon[165], too, was most cordial and Mr James Maxton[166], though the latter briskly repelled my suggestion that no doubt he had voted for me. Altogether I was made to appreciate that atmosphere of personal friendship which is one of the main strengths of the British Parliament of today. It was a little embarrassing throughout the afternoon to find myself under the close scrutiny of police and other officials who have to know by sight all the Members of the House of Commons.

My first session in the House was short. The long vacation extended through August and September, Parliament resuming on 22nd October, only to be prorogued on the 25th in anticipation of the General Election. It soon became obvious that my parliamentary duties demanded residence within easy reach of London. My fiancée and I considered various localities and various available houses and at last were lucky enough to find a house that suited us exactly, at the northern tip of Hertfordshire and only fourteen miles south of Cambridge. The name of the house, Dalny Veed, puzzled us at first but reference to a Russian dictionary showed it to be simply the Russian for 'Distant View' and we learned that the original owner had been in business in St. Petersburg and had recognised a field on the north side of the village of Barley and sloping to the south-east, as providing a perfect site for a dwelling house, which he duly proceeded to build. The house and its three and a half acres of ground were effectively enclosed in a triangle of roads, while the southerly slope suggested great possibilities for my future wife's skill in landscape gardening. We were married in the crypt below St. Stephen's Hall in the Palace of Westminster on 2nd April, 1936 and immediately settled down at Dalny Veed. During the parliamentary session we had to stay in London, but it was a great relief to retire each week-end from the noise and bustle of town.

My resignation of the Glasgow Professorship took effect as from 30th September, 1935, and there came to an end my long period of unbroken friendly relations with the governing body of the University of Glasgow. My only further communication with the University Court was to make over formally to my old department my scientific library, scientific instruments and my zoological collections – the latter of great scientific value, including as they did, not merely those of lungfish made by myself, in the Gran Chaco, but also those of *Polypterus* bequeathed to me by Budgett, of calcareous sponges bequeathed by Minchin[167], the Protozoa bequeathed by C.G. Martin. The severance of relations with the University Court did not, of course, affect my relations with the General Council – the general body of

graduates who had entrusted me with their representation in Parliament.

Nominations for the Scottish university seats in the General Election of 1935 took place on 2nd November – four candidates for three seats. This meant that the poll would be in accord with the principle of proportional representation, each constituent having a single transferable vote. The voting paper carried the names of the candidates in alphabetical order with the instruction to place the numerals etc. opposite the names of the candidates in the order of the voter's preference. The paper had to be signed by the voter in the presence of one witness who certified this by his own signature. The completed voting paper had to be posted to the Registrar of the University to which the voter belonged. I had already had experience in Glasgow of this method of voting in elections to membership of the Provincial Committee for the Training of Teachers and had learned to distrust its reliability in practice as it was found that many voters allocated their votes simply according to the order in which the candidates' names appeared on the printed list. In other words, the vote for a candidate depended not upon his general qualifications, but upon what happened to be the initial letter of his surname.

No doubt a university constituency with its relatively higher standard of education might be expected to show the working of Proportional Representation at its best, but many congratulatory letters received after the declaration of the poll showed the most astonishing and often ludicrous blunders and misunderstandings on the part of the voters. More than one enthusiast expressed the pleasure he had in giving my 'all three' of his votes; two highly placed legal luminaries voting for me succeeded in invalidating one another's voting papers. However, the result of the poll was satisfactory as my 'first preference' votes were 16,214 of which only 8,252 were required to place me at the top of the poll. The election was, however, marked by a deplorable tragedy, Noel Skelton, one of the three successful candidates, dying during the counting of the votes. The seat to which Skelton had been elected was declared vacant. I was placed in a somewhat delicate position in relation to the choice of a candidate for the vacant seat, as I received an urgent appeal to do what I could to facilitate the candidature of Mr Ramsay MacDonald – who as the first Labour Prime Minister had actually been the cause of my entry into party politics. However, the present position was that, while he was now a member of Mr Baldwin's Government as Lord President of the Council, he had failed to secure re-election to his former seat at the General Election. It was put to me that he must be got back into the House of Commons if he were to continue as Lord President, so would I do my best to favour his candidature? Ramsay MacDonald was duly elected and I had the privilege of a few months' friendship with that very interesting personality before his untimely death.

The vacancy caused by Ramsay MacDonald's death was filled by the election on 28th February,1938, of Sir John Anderson[168], an Edinburgh graduate of great distinction who had risen to be head of the Civil Service and thereafter had become a very famous Lieutenant-Governor of Bengal.

It was indeed a strange new world in which I found myself after my election to Parliament. As its very name indicates, Parliament functions by the method of debate, and my experience in the world of science had taught me to be profoundly suspicious of debate as a method of arriving at sound judgments. Eloquence and skill in advocacy were apt to be the determining factors, far outweighing mere statements of fact – however accurate, however carefully marshalled. Again, I had learned to appreciate the pitfalls which lie in the path of those making use of statistical evidence – pitfalls concerned on the one hand with the volume and reliability of the evidence, and on the other with its interpretation. And yet in the House of Commons I found the affairs of the nation being settled or at least ostensibly settled by debate; debate, moreover, in which statistical statements were often accepted as the most convincing arguments. In view of the multiplicity of subjects dealt with by Parliament, in any one of which there were necessarily a very small proportion of the members qualified by intimate personal knowledge, the great majority of speeches had to be spoken to a brief, provided in the case of Ministers by their departmental officials, in the case of backbenchers by a government department, by their Party's central organisation, or by some interested body outside. This 'speaking to a brief' was entirely alien to the methods of science, while on the other hand it is entirely in harmony with the training and day-to-day professional work of the barrister. It seemed to follow that the appropriate source for Members of a debating Parliament was the Bar rather than the laboratory. It was only occasionally that a Member equipped with expert personal knowledge was in a position to intervene effectively in a debate. This applied particularly to problems affecting trade and industry and it seemed to me regrettable that persons who had risen to a position of leadership in such affairs did not contribute a much larger proportion of membership. No doubt this is rendered impossible by the system of universal suffrage where the uneducated voter naturally adheres to the candidate who is least trammelled by knowledge or strict principles in portraying the rosy future which will follow the return of his particular Party to power.

Moreover, there is the regrettable psychological fact that actual knowledge has a paralysing effect upon eloquence. The man-in-the-street knows that Professor So-and-So is looked up to as the leading authority upon some particular subject. He asks him a definite question about that subject. 'What is the real truth about So-and-So?' The great man hums and haws and very likely refuses to commit himself further than to say that on the whole he thinks that at the present moment the balance of probability would appear to be on the side of such-and-such being the case. The questioner is naturally unsatisfied. He meets another man in the street and recounts his experience and he is told, 'You take it from me the real truth is so-and-so', and away he goes

completely satisfied. The fact, of course, is that the comparatively ignorant man, entirely unaware that there is more than one side to a problem, or the fanatic who wilfully ignores all but one, is thereby enabled to reach heights of eloquence that would otherwise be inaccessible.

An entertaining feature of our parliamentary system, which I had not fully appreciated until actually in the House, is the amount of make believe that enters into it. In my early days in Parliament, I was much impressed when a Minister got up and made a statement about some important matter of administration, how he had devoted much time to its consideration and now having considered it in all its aspects he had finally decided to do so-and-so. In time the impressiveness of ministerial statements became much diluted by the realisation that such statements, like the knowledge of facts on which they are based, are the work not of the Minister himself, but of the hard-working civil servants of his departments. Nevertheless, in accordance with the doctrine of ministerial responsibility, the fiction that they are the work of the Minister himself is accepted – and to him is accorded the praise or the blame which they earn. It is a strange system but it works well in ordinary circumstances owing in great part to the high reliability of our Civil Service and I have often wondered how much this is due to our public school system of education, in which the young entrant finds himself in a community of rather older boys in which he is taught to 'play the game' – that wonderful and characteristically British code of personal honour.

As it happened, the period of my membership of the House of Commons turned out to be the most interesting of all the periods of similar length in the whole history of the British Parliament, including as it did the demise of the Crown in 1936, the accession and abdication of Edward VIII, the Coronation of King George VI, a period of extraordinary complexity and difficulty in international affairs, the Second World War, the abandonment of the Indian Empire, and the nationalisation of great industries which had been built up by competitive private enterprise.

To the back-bencher in the House of Commons, more especially to one like myself who had come into it from a so different environment, it was of fascinating interest to watch the turning over of these pages of history, and apart from their historic importance these years have left behind many vivid memories. That dismal day in January 1936 when I watched the funeral procession of George V passing by to the mournful strains of the pipes, the coffin followed on foot by Edward VIII and great national figures of war and peace: the wonderful skill of Stanley Baldwin as he guided the House of Commons and the country during those anxious days of the abdication of King Edward: the marvellous pageantry of King George's coronation in Westminster Abbey: the anxious listening to Neville Chamberlain's latest reports from Germany: the declaration of war: the air-raid warnings and the temporary adjournments of the House on the intimation of 'imminent danger': the transference of sittings to Church House: the sight of what had been the House of Commons after its destruction on 10th May 1941: the punctuation of London life by the sounds of sirens, gunfire and bomb explosions: the strange metamorphosis of tube stations into dormitories: the citizens of London going about their daily work, picking their way amongst heaps of rubble and lines of fire-hose. During the war period I stayed usually in the Athenaeum until the hours of sitting were altered from 11 a.m. to 4 p.m. when it became possible to travel daily by train, subject to delay from bomb craters on the track. One day I spent 8 hours in the train. A break came when on 17th October 1940 I suffered a fracture to my right tibia at Euston Station during an air-raid. After a fortnight in hospital, I was conveyed home by ambulance on 29th October. A bed was rigged up in my library on the ground floor and there I remained peacefully recuperating until the end of January: peacefully apart from the occasional sounds of bombs and gunfire. It was somewhat trying when the sound of a distant bomb was followed by another and another distinctly nearer, rousing speculation on the possibility of one of the series hitting Dalny Veed. Nothing of the kind happened, however, until the evening of 28th November when my nurse was interrupted in her work of tidying me up for the night by a tremendous explosion accompanied by the tinkling of glass and the pouring into the room of a cloud of soot from the chimney. My wife rushed in to see that I was all right and then into the kitchen where a maid had been bowled over by the blast. A crowd of people, members of the Home Guard and others quickly assembled to inspect the damage, Dalny Veed being the first house in the neighbourhood to suffer from any enemy action. Actually, the damage was much less than it might have been, most of the windows were blown out, doors fractured and plaster cracked, and the absence of glass in the windows meant a certain amount of discomfort during the cold winter months when it was impossible to have them repaired.

Incendiary bombs were rather a nuisance. One evening I counted 62 blazing in a straight line along the hillside to the eastward. Another time five dropped in the garden of Dalny Veed, without, however, doing much damage, except that one destroyed a valuable and valued bed of young plants of shrubs, seedlings and cuttings. One was a dud and after it was rendered harmless, I was shocked to find, neatly engraved on its magnesium body the initials, not A.H. the initials of Adolf Hitler but G.K. I told my friends that it was this incident that caused me really to have a down on the Führer. As war went on a considerable number of bombs were sprinkled over the neighbourhood, due in part, I suspected, to the effectiveness of a fake aerodrome constructed close to Dalny Veed with the object of attracting enemy bombers away from a neighbouring aerodrome. In the later stages of the war, we saw to the south an occasional doodle bug (V.l) travelling towards London. A few miles to the South of Dalny Veed was a great American aerodrome with about 4,000 men, and it was a grief to us when we learned one day that the Commanding Officer, a personal friend, had been lost in one of their raids on Germany. He had told us that it was a rule of A.A.F that

Commanding Officers must take part in raids in their regular turn. Though that showed a highly commendable spirit, I wondered if it were really a sound policy to extend equal risks to persons in such key positions.

A complication arose when in 1938 I received a warm invitation from a group of socialists in the University of Glasgow to come and take part in a debate upon the government's foreign policy. From my experience in the House of Commons I had already developed strong objections to all open debates upon our relations with foreign countries. The Secretary of State for Foreign Affairs for the time being, who alone had at his command full knowledge of all the factors concerned, was to a great extent muzzled by that very knowledge. Other Members without these trammels were apt not merely to express entirely misleading opinions, but also to use language liable to cause disastrous reactions on the part of proud and patriotic foreign peoples. Accordingly, I refused absolutely my Glasgow colleagues' invitation and attention was drawn in the local press to this deplorable conduct of a Member of Parliament who refused to discuss an important section of government policy with his constituents. When publishing a justification of my behaviour I expressed the view that a most desirable reform of the procedure of the House of Commons would be to set up an all-Party committee on foreign relations where foreign affairs would be debated in secret so long as any matters of delicacy were at issue.

The dissolution of Parliament in 1945 at once raised the question as to whether or not I should stand again. On the one hand I had become disillusioned regarding my qualifications as a parliamentarian. On the other hand, was the danger that the seat vacated by me might quite possibly be taken by a socialist, while if I stood again there would surely remain a sufficiency of votes from my record poll of ten years earlier to give me a good chance of retaining the seat for my party. I eventually decided to be a candidate once again: when I received the report that on the first count I was at the bottom of the poll I lost interest in the matter, until there came the surprising news that the final count brought me out at the top!

A lesson already driven into my mind during the preceding Parliament was that parliamentary democracy, excellent in many ways as a form of government in normal times, becomes quite impossible in times of great national emergency. During the emergency of the World War, Parliament had no doubt continued to debate and discuss but the actual power had been concentrated in the hands of one man, Winston Churchill, aided in the details of government by his self-chosen advisers. So also in the U.S.A.: its war activities were similarly dominated by a benevolent dictator, Franklin D. Roosevelt, as also in other great powers – Stalin, Hitler, Mussolini. In every case, government was for the period of the emergency, a virtual autocracy.

After the Labour victory of 1945, in spite of the continuance of the national emergency, there was no longer a virtual autocrat at the head of the Cabinet, but the disparity in numbers between the two principal Parties was almost the same as during the preceding decade: 393/189 against 387/154. What made the disparity much more dangerous was that the new government was imbued with socialistic ideals that involved revolutionary changes in those relations between capital, management, and workers, under which our country had attained a position of prosperity and leadership among the nations of the world out of all proportion to its size and population; a position attained mainly through the hard work of citizens of outstanding ability in the fields of commerce, industry and applied science, and retained by continued effort backed by military and naval power. The now predominant party was all out against individual pre-eminence whether in ability, industry or income. Nature's dictum that no two individuals are born exactly equal must be defied: those who seem to be outstanding in ability, industry and earning power must be repressed. The ideal must be the nearest possible approximation to equality for all in the matter of privileges or remuneration. The intellectual ability from which spring great industrial developments or the organisation of great business concerns must on no account be regarded as being on a higher level than the physical ability to do the routine work of an ordinary labourer. I will not discuss the results which must automatically follow government along such lines in the case of an island community dependent for its very existence upon its success in competing in the markets of the world with countries in which private enterprise has full scope. All this will one day be recorded by a future Gibbon[169] when he writes 'The Decline and Fall of the British Empire'!

My parliamentary career and that of several others came to an end with the abolition of the university franchise by the Attlee government. I had, I confess, no great confidence in its persistence. Among parliamentarians there was always the suspicion that the university representative was apt to be independent minded and liable to speak and vote without due regard to party discipline. And among the outside public there was the feeling that the university seat was liable to be made use of on occasion to provide an easy entrance to Parliament for one who though devoid of university qualifications would be a desirable acquisition to a particular political party. And finally there had come into being in recent years special machinery for dealing with the relations between the universities and government, in the form of the Committee of Vice-Chancellors, which kept under constant review the affairs of the universities and their needs, and the University Grants Committee appointed to keep the government in touch with the needs of the universities and to advise regarding their financial aid.

As regards my own work in Parliament, it was not long before I discovered my mistake in accepting the assurance that I should be given plenty of work on parliamentary committees dealing with scientific matters. In point of fact, nothing of the kind happened. I was invited to take charge of a Bill from the Lords dealing with Scottish matrimonial affairs, and to serve

upon a departmental committee on Local Government in Scotland, with neither of which subjects did I possess any special familiarity. At the same time there were set up many committees dealing with matters in which I had special interest and experience – the training of medical students, the organisation of hospitals and medical schools, the need of bringing our ancient type of school education into relation with citizenship in the world today, the scientific development of fisheries and in general the food resources of the sea, and I would have dearly loved to find myself made use of on such committees. No doubt, apart from formal parliamentary committees, I was able to do a little on informal committees. An invitation came from Sir Francis Fremantle[170] to join the medical committee presided over by himself and later Dr A.B. Howitt[171], the meetings of which were always of interest and, during the pre-war period, of particular importance when its advice was sought on the organisation of hospitals and other medical arrangements for coping with possible war emergencies such as the bombing of London. Then periodical meetings of the university Members were convened and presided over by Sir Ernest Graham-Little[172] and meetings of Members for the discussions of post-war policy by Sir John Wardlaw-Milne[173]. All these three groups, though without the status of formal parliamentary committees, were able to do really useful work and I enjoyed taking part in their activities.

The main duty of a Member of Parliament is – as the word Parliament indicates – to speak, to take part in debate, and for the reasons already given I determined to restrict my speeches to matters to which I happened to have special knowledge: education, health service, fisheries and the commercial exploitation of the food resources of the sea, the construction of a ship canal across mid-Scotland, war camouflage.

Education

In my various speeches and questions dealing with education, I urged that surely the main object of our expenditure on education was training in citizenship – the qualifying to be a worthy citizen in our complicated modern community and that important factors in such training were the development of the powers of observation by eye and ear and the correct interpretation of what is observed, the development of mental alertness, and the development of such qualities as morality, personal honour, discipline, loyalty, manners, cleanliness of person and thought, command of the English language and the ability to express oneself clearly in speaking or writing. Such qualifications were surely of far greater importance in the life of the citizen than mere information, much of it useless, or if not, easily obtainable when required from books or otherwise, and yet the conveyance of mere information on a great variety of subjects and its memorising took up a large portion of the time spent in an ordinary day school. Incidentally, I stressed the transcendant importance of the pre-school period in laying the foundations on which school education must rest, and also the fact that education did not terminate with the end of the school period. The mental development in a boy of 14 when allowed to take part in adult activities in workshop or office was most impressive as compared with what happened if his period in an ordinary day school was extended through the great formative period of 14 – 16. As likely as not these two extra years meant his leaving school completely stale and devoid of all keenness to go on learning.

Health Services

A large part of my speaking was devoted to urging the importance of maintaining the great voluntary hospitals in view of the all-important part they played in the training of the medical students. Under existing conditions, the leaders in medical and surgical practice in the particular area were glad to take wards and to conduct clinical teaching in an honorary capacity. It was of immense benefit to the student to have available not merely the skilled technique of a master of his subject, but also the inspiration to do his best to attain a similar position of leadership with its accompanying honour and material benefits. Under existing conditions, as I had learned during my long experience of medical students, the profession of medicine was successful in attracting the most brilliant type of student. Were this attraction weakened by the disappearance of the great leaders of medical and surgical practice from their teaching activities, these brilliant students would assuredly turn their attention elsewhere – to industry, commerce or professions in which their individual ability would find its due reward, or should they be determined to stick to medicine, would go overseas to other lands in which they could freely compete. In either case they would be lost to our own country, and not merely the profession of medicine, but also the advancement of medical science, in which Britain had played an out-standing part in the past, would suffer a disastrous blow. I reminded the House of some of these advances – the foundation of antiseptic surgery by Lister, the introduction of chloroform as a general anaesthetic by Simpson[174], the invention of vaccination by Jenner[175], the foundation of tropical medicine by Patrick Manson[176].

Fisheries

Outside the House of Commons, when Chairman of the Advisory Committee on Fishery Research, I had been somewhat critical of the generally accepted ideas regarding overfishing and its effect in diminishing the food-fish population of the sea. Although the evidence of this was incontrovertible in the case of flat fish and other bottom frequenting fish, I felt that the possibility of serious fallacy underlay the evidence as regards other food fishes. This fallacy affected especially the evidence provided by the greatly increased catches by trawlers during the immediate post-war period which was interpreted as indicating increase in the fish population during the war period, when the activity of trawlers was greatly diminished. The fallacy underlying this evidence lay in the fact that fish are extremely sensitive to vibrations in the water and in the possibility of their learning to avoid the oncoming trawl through the necessarily great vibrations that it caused in the sea water. There was thus the possibility that the increased catches after the war period were merely expressive of

the fact that the trawls now encountered generations of fish which had not learned by experience to avoid the oncoming trawl. Evidence in favour of this interpretation was provided by the herring industry where the catches – by drift net instead of by trawl – showed no evidence of the herring population having undergone any reduction through human agency. Another aspect of the fisheries problem related to the plankton or drifting fauna of the sea which provides the food of such fish as the herring and mackerel, of the whalebone whales, and of oysters and other shellfish. The seas around our coasts were rich in plankton and therein existed untold amounts of highly nutritious food material, at present entirely untapped by man, except indirectly through the fish and shellfish which subsist upon it. The plankton is not evenly distributed: it shows concentration in particular sea areas or at particular depths. I suggested, without effect, that the government should appoint a committee – whose membership should include not merely marine biologists, but also engineering specialists in the technique of extracting solid particles from liquid – to advise on the possibility of collecting plankton on a commercial scale and making it available for human consumption.

Still another aspect of the fisheries problem was the importance of developing our oyster fisheries. In various other countries oysters were not merely expensive delicacies for the well-to-do, but constituted an important element in the food supply of the ordinary people. The sea lochs of the west of Scotland, with their rich supplies of oyster food in the form of plankton and their freedom from contamination by sewage from large towns, provided ideal localities for the development of oyster fisheries by planting out young oysters above the level of the mud which had played an important part in killing out the once abundant oyster population of these lochs. My speeches on the development of fisheries were not confined to those of Great Britain. The fisheries of our overseas possessions constituted an asset of great potential value, and it was of importance to give every help to their development by the institution of research centres and otherwise.

Forth–Clyde Ship Canal

During my years in Glasgow with frequent journeys to and from Edinburgh, my thoughts had often recurred to the old idea of a ship canal, uniting the Firths of Forth and Clyde and cutting through the barrier formed by Great Britain across one of the great trade routes of the world – between Canada and Northern U.S.A. on the west and Scandinavia and the Baltic on the east. While President of the Royal Philosophical Society of Glasgow, I had arranged a symposium on the subject from which it transpired that, on the one hand, the engineering difficulties were by no means insuperable, and on the other that shipping interests in Scandinavia and Northern Germany were prepared to make use of such a canal provided the rates were reasonable. Accordingly when in April 1942 the ballot assigned to me the opportunity of speaking to a Resolution on the Preservation and Development of Scottish Industry, I decided to emphasise particularly the industrial developments which might be counted upon to follow the construction of a Forth-Clyde ship canal.

My speech on 14th May 1942 sketched the history of the industrial revolution in mid-Scotland which followed the work of that Glasgow University artificer James Watt in making the steam engine economically practicable, and the inauguration of steam navigation by Symington's 'Charlotte Dundas' propelled along the Edinburgh-Glasgow canal by a James Watt engine. I recalled how the 'Charlotte Dundas' was inspected by the American Fulton[177] and how he ordered an engine from Messrs Boulton & Watt and fitted it into the 'Clermont' on the Hudson river – the first American steam-ship. I referred too to important subsequent steps in the development of steam navigation which had taken place in mid-Scotland; the first use of compound engines; the first construction of a sizeable vessel of steel; the first turbine-driven passenger steamship; the first high-pressure steamship engine. So too in other industries, particularly textile and heavy, mid-Scotland had been the seat of many important steps in their development. The location of particular industries was, however, not necessarily permanent: they were apt to migrate to other localities where the conditions were more favourable, as was exemplified by the dying out of the textile industry in the west of Scotland as it developed in Lancashire. A similar fate might be anticipated for the heavy industries which meant so much for the Scottish midlands today. The surest safeguard for the future would lie in the development of a variety of light industries, and such development would surely come about in the region opened to water transport by the Forth-Clyde canal just as it had in the case of the Manchester ship canal.

The main obstacle in the way of constructing the canal was its great cost together with the fact that the return on the expenditure would be indirect – by the new developments of industry in the region traversed by it. It could not be expected to pay a direct dividend for many a day. It followed that there was no possibility of the money being provided by private capitalists: it would have to be provided by the state. 'Great Britain interposes a tremendous obstacle in the path of commerce between the new world on the one hand, and Scandinavia, the Baltic countries and Germany on the other. Ships using the proposed canal would not only save hundreds of miles of steaming and many hours of expenditure of fuel but would also evade the dangers of the Pentland Firth. Such a canal would present an irresistible attraction to commerce'. 'In my mind's eye I see ships travelling, not across the arid deserts of Suez, not through the jungles of Panama, but through a prosperous, happy countryside dotted with garden cities, producing materials which these great ships can carry away, and where these great ships can refuel'.

I urged that the government should make at least a preliminary investigation of the scheme and expressed the hope that the Secretary of State would not leave a blot on the Official Records of Parliament like that of Lord Palmerston[178] who, when answering a question on

the proposed Suez Canal, referred to it as 'One of the many bubble schemes which from time to time have been palmed off upon gullible capitalists'. There was at the moment little reaction to my speech: the value of the canal scheme in terms of votes was insignificant. However, public interest gradually developed. In July 1943, the *Glasgow Herald* reported that 'indifference and even hostility' to the scheme were rapidly disappearing. The proposal was a canal from Grangemouth to a point near Clydebank, a distance of 29 miles. The canal would be at sea level without locks, except the sea-gate at each end, thus evading the difficulty of providing an adequate and reliable supply of fresh water for the working of locks.

Apart from its advantage as a short and safe cut for transatlantic shipping, it would serve to link together ports on our east and west coasts. The export trade, on which our country subsisted, was dependent upon our costs of production being low and competitive, and one of the important factors against this lay in the cost of transport between our manufacturing centres. This would be reduced by the availability of the relatively cheap water transport between centres of production.

The availability of water transport to the Scottish midlands would also be of particular value to the existing heavy industries, for our manufacture of iron and steel had been entirely dependent upon iron and ore, and the canal would bring this ore straight to the blast furnaces close by. In the opposite direction the manufactured steel would be available by cheap water transport to the shipyards of the Clyde. The enormous importance of such a canal in time of war was obvious. On the one hand, it would be free from the dangers of attack vessels which had hitherto to travel between east and west coasts by the long and exposed passage round the north of Scotland, and on the other hand it would provide direct communication between Rosyth and the shipbuilding and repairing yards of the Clyde. In the Upper House, Lord Teviot proposed a resolution in favour of the canal and the Minister of War Transport agreed to appoint a departmental committee to investigate the matter and draw up a confidential report. The scheme had already gained the support of Unionist Scottish M.P.'s and in February 1944 an all-Party meeting passed a resolution in its favour. A Member remarked that it was the first time he had ever known Scottish Members to be unanimous about anything! Matters seemed quite hopeful. For a very brief period, unfortunately. Vested interests became seriously alarmed. Leith would steal trade from Glasgow: Glasgow's competition would ruin Leith; existing transport interests would be seriously injured. The Chairman of the Glasgow Chamber of Commerce denounced it as a 'wild cat's' scheme, the same epithet as had been applied to the Panama Canal. With existing business interests almost unanimously opposed, the position was hopeless, while public interest in Scotland was diverted to the two rival post-war schemes – the development of Prestwick airport and the construction of a road bridge across the Firth of Forth. And so the Forth-Clyde Ship Canal project once again fell asleep.

War Camouflage

The incidence of the Second World War during the period of my membership of the House of Commons gave me the opportunity of returning to my old interest, the utilisation in war camouflage of devices worked out by nature for rendering wild animals less easily recognisable and during the first three years of the war, I bombarded the Ministers concerned with questions drawing attention to the failure to secure adequate accord with scientific principles on the part of the artists who had been placed in control of war camouflage.

The tale had begun with my presence in 1895 at the opening of the Kiel Canal, recognised openly in Germany at the time as a preliminary move towards war with England. For the occasion, there had assembled an immense concourse of warships, each naval power contributing a squadron. What at once excited my interest was the fact that the vessels of Germany and of France were painted in a uniform grey colour – differing in shade in the two cases – obviously meant to have an obliterative function, to make the vessel less easily recognisable at a distance or in faint light. The fact, however, that the ships were painted of a uniform colour betrayed complete ignorance of these methods of obliterative coloration which had been evolved by nature in the course of countless ages for the concealment of wild animals for their enemies of prey, and which had been driven so forcibly on my attention by my observation of wild animals in the tropics of South America. Realising how greatly the obliterative effect of the ships' colouring could be increased by utilising nature's methods, I determined to do my best to secure their utilisation in the painting of our ships in the event of war. I prepared a short memorandum on the subject and on my return to Glasgow after the outbreak of war in 1914, forwarded it to Mr Winston Churchill who was then First Lord of the Admiralty. In due course I received a letter signed by Sir W. Grahame Greene[179], Secretary to the Admiralty, dated December 19th 1914, and saying 'I am commanded by My Lords Commissioners of the Admiralty to convey to you their thanks for the valuable information you have placed at their disposal and to inform you that the data and suggestions contained in your memo. have been communicated confidentially to the Fleet in a General Order'. The exact wording of my memorandum as circulated was as follows:

It is possible to diminish greatly the conspicuousness of ships at a distance by paying attention to the principles which govern the coloration of wild animals and render them so extraordinarily inconspicuous in their natural surroundings.

I Colour

Small animals such as insects, lizards, etc. are in many cases practically invisible when placed against their natural background on account of their tint and colour-pattern identical with that of their background. This principle of protective tinting is, however, of little importance in the case of large animals and it may safely be ignored entirely in regard to large objects such as

ships.

II Compensating Shading
If you take a large object, say a large sphere or ball, and paint it a uniform colour – say a reddish brown – and place behind it a screen painted with exactly the same colour, you will find on going back some distance that the sphere, instead of being inconspicuous, stands out from the background with the greatest distinctness (I assume the experiment is done in the open, with light falling from above – that is to say under natural conditions). The cause of this conspicuousness is that the brilliant lighting of the upper surface of the sphere gives it the appearance of being much lighter than the background, while the shadow causes the under surface to look very much darker. If you repeat this experiment with large animals instead of an artificially painted object, you will find, in many cases that the animal is almost completely invisible at a short distance when placed in front of a background of the same tint as itself. This is due to the fur of the animal being shaded in such a manner as to compensate for the different brightness of illumination on its back and on its belly. The back is darker (sometimes a very dark line runs along the middle of the back), the belly is lighter (often quite white), and the sides of the body are delicately graduated in shade between these two extremes.

This principle of compensating shading should be constantly borne in mind in painting the upper works of the ships. All deep shadows should be picked out in the most brilliant white paint, and where there is a gradually deepening shadow this should be eliminated by gradually shading off the paint from the ordinary grey to pure white. Big guns should remain the ordinary grey along their upper side (only a narrow strip, say 6 inches wide in the case of a 12 inch or 13.5 inch gun) and this should shade off into pure white along their lower surfaces. A neighbouring ship should be asked to advise as the work proceeds until the maximum of 'invisibility' is reached.

III Continuity of Surface
Observation of distant objects, e.g. ships, shows that their visibility depends upon their forming each a continuous spot or blotch standing out against a darker or lighter background. The continuous lines which form the boundaries of the object are the most important in rendering it conspicuous – e.g. in the case of a ship, the straight lines which form the outline of its spars and hull; in the case of an animal, the regular continuity of the outline. To counteract this, it is essential to break up the regularity of outline, and this can easily be effected by strongly contrasting shades. The same applies to the surface generally – a continuous uniform shade renders conspicuousness. This also can be counteracted by breaking up the surface by violently contrasting pigments. A giraffe or zebra or jaguar looks extra-ordinarily conspicuous in a museum, but in nature, when not moving, is wonderfully difficult to pick up, especially in twilight. Ring plovers, turnstones and many other birds and mammals, are rendered extremely difficult to detect, by the outline and surface being broken up by the patches of white.

This same principle should be made use of in painting ships. The outline more particularly should be broken up by patches of white. The masts should have irregularly edged bands of white surrounding them, the width of the bands, whether white or grey, being roughly about the same as the diameter of the mast. (It is important to break up the masts in this way, as doing so will help not merely to make the vessel less conspicuous but will greatly increase the difficulty of accurate range-finding). The bow, stern and upper line of the hull should also be broken up by very large patches of white, and what has been said naturally applies also to turrets and other parts of the upper works, fire control stations, etc., in every case destroy completely the continuity of outline by splashes of white.
(signed) J. Graham Kerr, September 24th 1914

In view of the controversial statements on the subject of camouflage after the close of the 1914-18 war, it is necessary to explain that the artists who were in control of war camouflage from 1917 onwards made use of the term DAZZLE for the breaking up of continuity of surface and outline by patches of strongly contrasting pigments, and the term COUNTERSHADING for what I called compensating shading. Both of these terms were borrowed from Thayer[180].

After the circulation of my 1914 memorandum, I was fairly confident that the painting of our warships would proceed along correct lines, an elementary knowledge of the scientific principles involved having been widely spread amongst service personnel by my very simply worded statement. But alas! My confidence turned out to be misplaced, for along with the memorandum was circulated the ominous note, 'The trial or adoption of the proposals made therein is left to the discretion of Flag Officers, etc. concerned.' There was no suggestion of special officers being appointed to see that the camouflage was properly carried out on an organised system. The natural result was a complete lack of uniformity in carrying out the coloration of the individual ships which varied according to the reaction of the Flag Officers or others concerned. To some, the idea that the colouring to which they were accustomed should be replaced by a ridiculous patchwork seemed simply an outrage. Those who took it more seriously and did endeavour to paint their ships in accordance with the memorandum were apt to fail in particular details such as the scale of the patchwork or the violence of the contrast between the pigmentation of the patches. There seemed also a tendency to forget that the diminution of visibility was of importance not merely as regards the ship as a whole but still more so as to the details of its structure.

The sudden appearance of dazzled warships all over the world in 1914-15 naturally attracted the attention of everyone interested in shipping. There was much talk of it in Glasgow, while private information came to me about the excitement among service people in the Mediterranean and how our troops in Gallipoli were

mystified by the vessels anchored off-shore, the dazzle painting making it difficult to see how individual ships were heading. In Bermuda, during the winter of 1914-15, Abbot H. Thayer, the originator of the terms dazzle and countershading, at once recognised that the camouflaged ships were more or less foozled attempts to carry out coloration in accord with the scientific principles of animal coloration with which he was so familiar. Being strongly pro-British, he decided to offer his services to our government and actually came over to this country to do so. Armed with recommendations from Professor Poulton[181] of Oxford and myself, he endeavoured to get in touch with our authorities but failed entirely. He found them, as he said, surrounded by a quite 'impenetrable net of courtesy'. As time went on it became obvious that the Admiralty's interest in dazzle was fading out in view of the divergent reports on its utility, and I attributed this to the frequency with which the suggestions in my memorandum were not carried out effectively. This in turn made me feel it desirable to supplement my first memorandum by one less abbreviated. Accordingly I sent to the Admiralty in July 1915 a fuller communication (Admiralty No. DO 3126/15) and again in December 1915. In these I expanded the wording of my original memorandum so as to make its meaning still more clear and drive home its contents still more forcibly.

I again emphasized that a uniform coloration was necessarily wrong, as except on very rare occasions it caused the ship to stand out clearly as a continuous blotch or patch and that the only method of correcting this was to break up the continuity of surface and outline into areas of violently contrasting shade or tone. I also met the criticism which had come from the Admiralty in a letter dated 9th July 1915, that 'the strong variations of light and surroundings that are liable to be experienced at sea, render it necessary to modify considerably any theory based upon the analogy of animals', by pointing out that such variations are quite trifling compared with those experienced by a dazzled animal such as a jaguar. I emphasized that the object to be aimed at was not so much complete invisibility of the ship as a whole, as the invisibility of the details of its upper works which on the one hand betray its character and on the other hand by their perspective enable the range taken to judge how the ship is heading, an important matter to the gun layer when aiming at a ship under way. In the matter of such details, I emphasized the particular importance of countershading in the case of guns and torpedo tubes, and in the case of deep shadows which should be diminished so far as possible by the use of brilliant white paint. The importance of scale in the dazzle patchwork was again emphasized, a small scale patchwork becoming at a distance no better than a uniform colouring.

I failed to see any immediate result of these communications: the Admiralty apparently adhered to a decision (letter of 9th July 1915) to use a system of colouring which ignored the dazzle principle. It was not until the autumn of 1917 that a naval friend reported to me that my system of camouflage had reappeared but that it was said to be a new invention by an artist. It was in fact a very distinguished artist, Mr Norman Wilkinson[182], who succeeded in reawakening the Admiralty's interest in dazzle. He was placed in control of camouflage and was allowed to select his own staff of some 40 assistants. Accommodation for experimental work on models was provided by the Royal Academy and camouflage officers were appointed at the various seaports. My 1914 memorandum had to do with the camouflage of ships, but of course the visibility of other things of importance in war is determined by exactly the same factors and I made many attempts to urge this upon the authorities. Already in my letter of 5th December 1915 I had done this as regards guns, armoured cars, uniforms. The flat top of the service cap ignoring scientific principles and reflecting the light formed an ideal target for the enemy marksman in the case of troops lying prone with their heads towards the enemy.

While aeroplanes against a background of sky provided a problem of great difficulty, the construction of the wings of transparent material and the use of brilliant white for the under surface as in sea birds which had to be concealed in flight from their fish prey were recommended. A letter to Mr Lloyd George, dated 28th September 1916, emphasized these recommendations about aeroplanes and in addition urged that special planes for night use should be painted on their lower surfaces with matt black varnish. On clear nights without a background of cloud or haze they would be completely invisible, even when in the beam of a searchlight. The letter of acknowledgement, dated 10th October, informed me that 'its subject matter is forming the basis of detailed investigation'. During the war my various communications on the subject of camouflage were, of course, secret, but after its close I published a general statement on the subject in a letter to *The Times* (May 6th 1919). My letter was followed by an outburst of publicity which must have convinced the general public, knowing nothing of the inner history of the matter, that dazzle was the invention not of nature but of Mr Norman Wilkinson.

Eventually I received a letter from the Admiralty, dated 20th October 1920, saying that 'several claims in respect of dazzle painting, etc., are receiving the consideration of the Royal Commission on Awards to Inventors' and suggesting that I might apply to them. Though I had made it quite clear that what I was interested in was not a pecuniary award but official admission that 'dazzle' was no invention by an artist but simply an application to war camouflage of certain recognised scientific principles, I decided to submit my application. The Commissioners – amongst whom there was no biologist – in their report made no pronouncement on the *origin* of dazzle. On the one hand, the chairman ruled that they were not concerned with the matter of personal controversy (Minutes, p. 106). On the other hand, the evidence given before the Commissioners and duly recorded in the Official Minutes contains statements surely calculated to make their confusion of ideas worse confounded. As regards the term 'dazzle' invented by Thayer and used by him in connection with animal

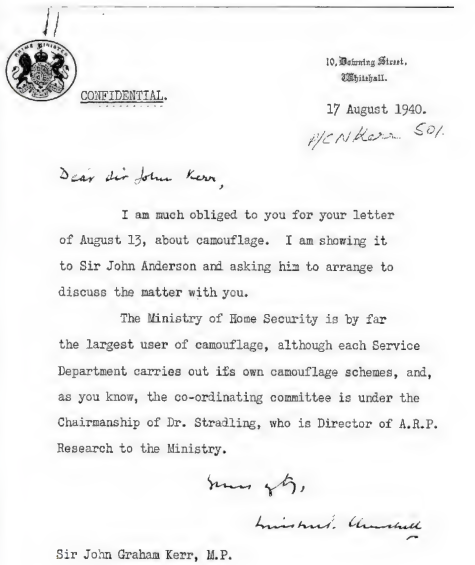
camouflage long before the war, 'Admiral Greatorex invented the word,' 'the word was chosen for the purpose of contrasting it with camouflage'! As regards the idea of applying dazzle to the coloration of ships, 'the idea suddenly came to him (Mr Norman Wilkinson) on the 26th April 1917, as he sat in a carriage'. No mention of his experience in the Mediterranean during the outburst of dazzle in 1915. The function of dazzle 'has nothing to do with visibility' (page 5). On the other hand the Royal Commission very properly recommended an award to Mr Norman Wilkinson for his work in getting dazzle put into effect on a large scale in 1917. During the period between the wars, public information about war camouflage continued to be dominated by the artists. Mr Norman Wilkinson's article in the *Encyclopedia Britannica*, Fourteenth Edition, 1929, says in regard to the dazzle painting of ships in 1917, 'it embodied entirely new ideas in sea camouflage' and makes no mention of its experimental employment in 1914-15 nor of its biological foundations.

With the approach of World War II, I fondly imagined that I would at long last be able to secure that camouflage should be put under scientific control, but it was not to be, and later it was most frustrating to see in the Malayan campaign the highly successful adoption of my dazzle painting principles by the Japanese. A letter to the Prime Minister in March 1936 served merely to start a tiresome and controversial campaign – involving many letters to Ministers and some 40 questions in the House of Commons – which resolved itself into a practically single-handed conflict between myself as representing the scientific side of camouflage and the artists who remained in official control. As there still continued the official denial that naval dazzle was identical with or had anything to do with what had been set forth and promulgated to the Fleet in 1914, I agreed to allow the publication *verbatim* of my original memorandum (*Nautical Magazine*, July 1940). I should have mentioned that before the actual outbreak of war there had appeared in *The Times* an admirable article – with which I personally had nothing to do – upon camouflage which was obviously written by someone with full command of the scientific principles involved, and might well have been taken as a guide by the officials responsible. Nothing of the kind happened and the artists continued on their way.

Even more to be deplored than the answers to questions in the House – evasive, misleading, or grossly inaccurate – was the consistent barring out of scientists from positions in which they could exert direct influence upon the practical application of camouflage. I was personally barred out from the membership of any camouflage committee; from appearing before any such committee; from interviewing the Prime Minister; from appearing as I requested before the War Cabinet. In view of ineffective efforts in such directions, I concentrated upon trying to infiltrate into the camouflage organisation someone highly qualified in the scientific aspects of camouflage, and had the good fortune to find available one of the chief living authorities upon the camouflage of animals, Dr Hugh Cott[183] of Cambridge (Fig. 15). Dr Cott was already known to the authorities. He had lectured with much acceptance at the Staff College, Camberley, and had also delivered an impressive exposition of the scientific principles of camouflage to Members of Parliament in the Grand Committee Room, Westminster Hall. At the close of this address, he was invited to an interview with Sir Kingsley Wood[184], Minister for Air. An outcome of this was his being entrusted with the task of camouflaging an area containing objects of military importance in one of our chief aerodromes. His work completed, it was flown over by the authorities –military and ministerial – and pronounced unanimously to be extraordinarily effective. At last all seemed 'set fair' and I visualised Cott's immediate incorporation into the service and his skilled technique being made available to the country. Nothing of the kind happened, and on my asking why, there came the astonishing reply that though Cott's work at the aerodrome in question had been excellent, the cost had been too great. This in spite of the fact that he had been practically authorised to use his own judgment as to what was necessary in the way of expenditure. However, Cott was given another chance – the obliterative coloration of an ordinary large, 9.2 inch coastal defence gun! Such an object catches the eye at once, its long cylindrical form standing out conspicuously whatever its surroundings. The effectiveness of the result achieved by Cott was of the same order as that of his former experiment. An airman provided with a vague indication that the gun was situated near a particular railway station failed entirely to find it. Even when the precise location was 'pin-pointed' it was only when the plane came down to 2000 feet that the gun became visible. I was able to show a number of photographs of the gun taken from the air to General Dill[185], C.I.G.S., and to several other highly-placed officers and they were one and all greatly impressed. The General having at last found the gun remarked that he seemed to see right through it.

So again all seemed 'set fair'. Cott had worked out and solved the problem of how a gun ought to be camouflaged to secure the most perfect obliterative effect, and it would obviously be within the capacity of ordinary workmen to paint other guns as exact copies of Cott's gun. As I could see no evidence of this being done, I put a question in the House of Commons (8.1.42) asking the Minister 'whether any steps were taken to secure the immediate extension of this protection to every gun in the service, ashore or afloat; and whether he will inform the House if in the public interest, what obstacles have prevented this from being carried into effect'. The Minister replied, 'I can assure my hon. friend that the Army has taken full advantage of the biological knowledge of the specialist referred to and that no obstacles have been placed in the way of its proper application'. Apart from the mere untruth involved in this answer, it was of course obvious that not a mere lack of obstruction, but actual constructive orders on the part of those in control of camouflage were required.

Fig. 15. Hugh Cott. (Photo: Department of Zoology Archives/University of Glasgow)



10, Downing Street,
Whitehall.

CONFIDENTIAL.

17 August 1940.

H/CN Kerr 501.

Dear Sir John Kerr,

I am much obliged to you for your letter of August 13, about camouflage. I am showing it to Sir John Anderson and asking him to arrange to discuss the matter with you.

The Ministry of Home Security is by far the largest user of camouflage, although each Service Department carries out its own camouflage schemes, and, as you know, the co-ordinating committee is under the Chairmanship of Dr. Stradling, who is Director of A.R.P. Research to the Ministry.

Yours ever,

Winston S. Churchill

Sir John Graham Kerr, M.P.

Fig. 16. Letter from Churchill to JGK concerning camouflage. Image courtesy of University of Glasgow Archives & Special Collections, John Graham Kerr collection, GB248 DC 006/501. Reproduced with permission of Curtis Brown, London on behalf of The Estate of Winston S. Churchill © The Estate of Winston S. Churchill.

I had already, in a speech in the House (23.10.41), drawn attention to the wrongly camouflaged guns in one of H.M. ships and said I had used exactly the same words of criticism of a camouflaged gun on a previous occasion – that particular occasion being in a letter to the Secretary of the Admiralty, dated 18th July 1915! In my speech I made it clear that my attacks on the inefficiency of our war camouflage related entirely to the failure to take full advantage of the potentialities of paint in this connexion. There were, of course, many other methods of misleading the enemy in the matter of objects of military importance – hiding them under an innocent-looking covering; distracting the enemy's attention by providing dummies; eliminating shadows by substituting sloping or vertical walls, and so on. Such types of what might be called structural camouflage had been used most effectively. The supreme advantage of paint as a means of camouflage was its transportability. A covering of vegetation harmonising with the surroundings may form a perfect camouflage for a small ship moored in a creek, or a stationary tank, but a moving object must have a means of camouflage which automatically accompanies it, and such is provided by properly applied paint. Although the immediate reaction to questions in the House as to letters to Ministers was uniformly depressing, there did come about a gradual improvement in service camouflage, especially as regards ships (Fig. 16). The need of violent contrast in the elements of the dazzle patchwork and their being drawn out horizontally rather than vertically, became more and more clearly appreciated. One of the gratifying features was the acceptance at long last of the utility of white as the element in the effective camouflage of ships. I had stressed this in my original memorandum of 1914, but its use was neglected by the artists in charge, and a letter to the First Lord, dated 9th September 1939 brought the reply that 'The instructions to ship-owners are that all merchant ships should be painted in an even colour with a matt surface, avoiding light shades, and in particular, white, which shows up very clearly at night' – the actual fact being, of course, that against a background of sea or sky, in normal circumstances, white is the least conspicuous of all colours. A port authority which painted its navigation buoys white instead of red or black would be regarded as insane.

I have told in outline the tale of my efforts to secure that our country's war camouflage should have the advantage of scientific guidance. I have confined myself in the main to naval camouflage but, of course, my efforts extended to land camouflage, the effectiveness of which is ruled by precisely the same set of principles. Aerodrome hangers, oil tanks, buildings, vehicles, aeroplanes, uniforms, all formed the subject from time to time of communications to government departments or of questions in the House of Commons. It was in regard to military camouflage on land that scientific method was at last able to make itself really effective. Cott was eventually given a commission in the Royal Engineers to do camouflage, but instead of being kept at home to influence its central administration, he was sent overseas and became Chief Instructor in Camouflage to the army in North Africa. Soldiers who went through that campaign are well aware how effective its camouflage methods became and what an important part it played in the attainment of victory.

When parliamentary duties no longer made calls on my attention and when the Second World War was over, and lands and seas were free from fear of attack, we made good use of the summer months in travelling abroad and seeing other countries than our own. Our first adventure was Finland where I represented the Royal Society at the Tercentenary Celebrations of the Royal Society of Finland. My wife, in full court dress (as commanded) listened to speeches in languages unknown to us – then one in German, which we could follow and find interesting. The hall was filled by scientists from many countries all decorated with orders and insignia: only the British scientists had nothing of that sort to mark the recognition of their services. Still, undecorated as I was as the representative of the Royal Society – the greatest scientific society in the world – I was given the first place and every possible consideration and token of respect. It was interesting to find amongst the people of importance introduced to us Scottish names, familiar to us – Ramsays – Brown or Brun.

In other years we sailed down the east coast of Africa stopping at Mombasa and Nairobi – Dar-es-Salam and Zanzibar – and at the Cape where we had relations with whom we stayed. Then to Germany where we stayed several times with Sir Brian Robertson[186] (now Lord Robertson) then U.K. High Commissioner of the Allied High Commission in Germany. He had married a cousin of my wife and we were most delightfully at home in their house – in Germany and later in Egypt where he was Commander in Chief of the Middle East Land Forces – with them we came in touch with most interesting people – many of them in important posts in the army or representing it in governments.

A quite important incident gave me pleasure and so I relate it. Lord Mountbatten was a guest while we were with them at Fayid on the Suez Canal – the Robertsons and Lord Mountbatten were to attend an official dinner at Ismailia – they were to leave some time before our dinner hour - however, when we appeared we found the official party still there and waiting for us because Lord Mountbatten would not leave until he had greeted me – he flung his arms round me, hugged me to his heart, saying 'we are both Honorary Fellows of Christs' and Christs' Fellows must be great men for there are only four of us' and that was true, there were at that time only he and I, Sir Charles Darwin[187] and I think a Bishop.

On those words spoken by that distinguished sailor were tied together the memories of my life early and late, that are never far from me, and on that note of unbroken friendship I bring to an end this picture of my life which I have named *A Gallery of Memories* (Fig.17).

Fig. 17. JGK reading at his desk. (Photo: Department of Zoology Archives/University of Glasgow)

APPENDIX

Notes compiled by the editors
Some individuals are mentioned more than once in the text. For simplicity, we have not generally given a number for every time they are mentioned, only the first.

1. JGK's father James Kerr wrote: *The Domestic Life, Character and Customs of the Natives of India* (1865); *The Land of Ind (or Glimpses of India)* (1873); *Essays on Castism and Sectism* (1879); and *Carlyle as Seen in his Works* (1887).
2. Painted in 1872.
3. Alexander Dickson (1836-1887); Scottish botanist, latterly Professor of Botany at Edinburgh University and keeper of the Royal Botanic Gardens Edinburgh
4. "Zoophyte" is an older term for animals with characteristics similar to those of plants (fixed to the substrate; branching structure) and previously thought to be intermediate between animals and plants. *Sertularia* is a genus of hydroids (phylum Cnidaria).
5. Sir Patrick Geddes (1854-1932) was a botanist, zoologist, geographer and sociologist, remembered now as a pioneer of town planning.
6. J.M. Macfarlane (1853-1943) became Professor of Botany at the University of Pennsylvania and wrote books on evolution.
7. Sir Isaac Bayley Balfour (1853-1922) was Professor of Botany at the University of Glasgow, then Oxford, then Edinburgh, where he also became Regius Keeper of the Royal Botanic Gardens, directing considerable re-organisation.
8. William Jackson Hooker (1785-1865) moved from the University of Glasgow to become first Keeper of the Royal Botanic Gardens at Kew; he was succeeded by his son, Joseph Dalton Hooker (1817-1911), one of Darwin's key supporters.
9. James Geikie (1839-1915) was an authority on the Ice Ages.
10. Sir William Turner (1832-1916), author of the compendious *Atlas of Human Anatomy and Physiology* at age 25, became Professor of Anatomy at Edinburgh, and later University Principal. William Rutherford (1839-1899), Professor of Physiology, Edinburgh, for 25 years. Arthur Conan Doyle's fictional Professor Challenger, in *The Lost World* and other books is said to be partly based on Rutherford.
11. Peter Tait (1831-1901) was a mathematical physicist of high research productivity: he is estimated to have completed a research paper every 44 days on average. He collaborated with Lord Kelvin at the University of Glasgow on a series of textbooks. Denley and Pritchard (1993) reviewed his 13 papers on the paths of spherical projectiles, including golf balls (*The Mathematical Gazette* 77, 298-313).
12. *Marmion: a Tale of Flodden Field* (1808) - a historical romance in verse.
13. In fact, there have been 27 sightings of walrus in U.K. waters over the last 130 years, most recently in 2021.
14. J.C. Ewart (1851-1933) held zoology posts in University College London and Aberdeen University, before Edinburgh. His paper on the skate electric organ was published in the *Philosophical Transactions of the Royal Society, London* 179, 399-416 (1888).
15. Sir John Murray (1841-1914) is recognised as the father of modern oceanography. He served four years as naturalist on *The Challenger* expedition, and later took over directing the publication of its reports (50 volumes, 1896). The Scottish Marine Station, the first of its kind in the U.K., was a floating barge in the drowned tidal quarry of Granton, near the port of Leith. The station moved to Millport on the isle of Cumbrae in the Clyde estuary in 1894, as the base of the Scottish Marine Biological Association. J.T. Cunningham (1859-1935) was known for experiments on flatfish which he thought (incorrectly) demonstrated Lamarckian inheritance.
16. He read the advert in February 1889 at the age of 19, and was hardly "a properly qualified naturalist". But neither was Darwin at 22 when he joined *The Beagle*.
17. In his book, JGK cites Charles Waterton's *Wanderings in South America* (1825), Charles Darwin's *Voyage of the Beagle* (1839) and Henry Walter Bates's *The Naturalist on the River Amazons* (1863). Alfred Russell Wallace's book on South America was *A Narrative of Travels on the Amazon and Rio Negro* (1853).
18. The drawing is on page 138 of Kerr, J.G. (1950). *A Naturalist in the Gran Chaco*. Cambridge University Press.
19. *Pontederia* is a genus of aquatic plants endemic to the Americas.
20. Burmeister (1807-1892) was a German zoologist who spent the latter part of his career in Argentina, establishing the zoological collections of the national museum. He described many new species, especially amphibians and reptiles.
21. Gardener (or leaf-cutter) ants use leaves as nourishment for the highly modified fungi which grow in their nests. The adult ants cut and transport leaves, and keep the nests free of pests and moulds. Ant larvae feed on the fungal hyphae.
22. Spanish common name for the capybara (*Hydrochoerus hydrochaeris*), the largest species of rodent.
23. *Pistia* is a genus of aquatic plants in the arum family (phylum Araceae). Common name, water lettuce.
24. The giant water lily *Victoria regia* is the second largest in the family Nymphaeaceae, with leaves up to thee metres in diameter.

25. IUCN (International Union for Conservation of Nature) recognises three species of *Rhea,* the South American ratites (flightless birds), distantly related to ostriches. In the Chaco, most likely the greater rhea *R. americana,* a little smaller than an emu.
26. There are many species of South American deer, so it is not clear which JGK saw. The Spanish for deer is ciervo, so it is unclear why he gives cierbo.
27. This is most likely one of 16 species in the genus *Brachygastra*, the only kinds of wasps to collect nectar and make a kind of honey in their nests.
28. In his Gran Chaco book, JGK writes that he was able to transport home a limited part of his collections, especially bird skins. A few of these remain extant in the Hunterian Zoology Museum. The birds were reported as Kerr, J.G. (1892). On the avifauna of the lower Pilcomayo. *The Ibis* 4 (6th series), 120-131. The specimens left on *The Bolivia* never reached him.
29. Sir Edwin Ray Lankester (1847-1913); eminent teacher of zoology, researcher mainly on invertebrates. Based at University College London, then Oxford.
30. Philip Lutley Sclater (1829-1913) was a lawyer and zoologist, mainly interested in birds. Secretary of the Zoological Society of London for 42 years, and founder editor of the journal *The Ibis*.
31. Sir Arthur Shipley (1861-1927) was a Cambridge zoologist, tutor in the natural sciences from 1892 and eventually the university's Vice-Chancellor.
32. William Paley (1743-1805) was an English clergyman and philosopher. His *Natural Theology* (or *Evidences for the Existence and Attributes of the Deity*) (1809, published after his death) used the analogy of the watchmaker, taken up later by Richard Dawkins in *The Blind Watchmaker* (1986).
33. Jan C. Smuts (1870-1950); South African statesman, military leader and philosopher. After legal training at Cambridge and London, returned to South Africa in 1894 and became a key figure in the country's politics.
34. Sir Edward Burnett Tylor (1832-1917); an ethnographer who helped define the scope of anthropology. Believed human society underwent evolution from savagery to civilisation.
35. Henry Jackson (1839-1921), scholar of ancient Greek philosophy; became Professor of Greek at Cambridge.
36. Sir James George Frazer (1854-1941); Glasgow-born and educated social anthropologist interested in the origins of myths and religions. Famous for his book *The Golden Bough* (1840).
37. Alfred Newton (1829-1907); Professor of Comparative Anatomy at Cambridge; specialist in ornithology; wrote a four volume *Dictionary of Birds*.
38. Arthur Humble Evans (1855-1943); Cambridge lecturer in English history and economics, but also an ornithologist. Co-edited *The Ibis* with Sclater.
39. Sir William Somerville (1860-1932); Scottish-born and educated Professor of Agriculture, latterly at Oxford.
40. Sir Albert Seward (1863-1941) was particularly active in palaeobotany. Professor of Botany at Cambridge.
41. Sir Arthur Tansley (1871-1955) was a pioneer of ecology: first president of the British Ecological Society and first chair of the Nature Conservancy; Vernon Herbert Blackman (1872-1967) was a British botanist.
42. Lord Ernest Rutherford (1871-1937); New Zealand-born physicist, pioneer of atomic and nuclear physics; Nobel laureate.
43. Sir Joseph John Thomson (1856-1940); physicist, famous for discovering the electron and the existence of isotopes.
44. John Ray (1627-1705); the most prominent English naturalist of the 17th century, a pioneer of taxonomy.
45. Sir George Stokes (1819-1903); Irish-born physicist and mathematician, known for research on fluid mechanics.
46. William Henry Hudson (1841-1922); Anglo-Argentinian natural historian and ornithologist. Prolific writer of nature books, but also of fiction.
47. Sir Henry Hamilton Johnson (1858-1927); African explorer, botanist and colonial administrator. His name is associated with the scientific description of the okapi (*Okapia johnstoni*), a relative of the giraffe.
48. Sir Michael Foster (1836-1907); physiologist at University College London, then Cambridge. Known for teaching and administration rather than research. Secretary to the Royal Society and MP for the University of London. Sideline in the taxonomy of irises.
49. Adam Sedgwick (1854-1913) taught zoology at Cambridge, then Imperial College London. Not to be confused with his uncle of the same name, who taught Darwin geology but never accepted Darwin's ideas on the origin of species.
50. William Bateson (1861-1926) was the first person to use the term genetics, and was a promoter of the ideas of Gregor Mendel on heredity; after his early career at Cambridge, Bateson became Director of the John Innes Horticultural Institution. Hans Friedrich Gadow (1855-1928) was a German zoologist who spent most of his career at Cambridge, specialising in ornithology. Sir Sidney Frederic Harmer (1862-1950) was keeper of the zoology museum in Cambridge, then moved to the Natural History Museum, London.
51. Francis Maitland Balfour (1851-1882); born in Edinburgh, higher education at Cambridge. The leading British comparative and evolutionary embryologist of his time. Tragically died on Mont Blanc, aged 30.
52. The chambered or pearly nautilus (*Nautilus pompilius*) is an oceanic cephalopod, native to the south Pacific. Cephalopods are now divided into two subclasses: Coleoidea - octopuses, squid, cuttlefish; and Nautiloidea - nautilus.
53. Published as Kerr, J.G. (1895). On some points in the anatomy of *Nautilus pompilius*. *Proceedings of the Zoological Society of London* 1895, 664-686.
54. There are eight species of South American horned toads, family Ceratophryidae, two of them native to Argentina: Gadow's specimen was most likely *Ceratophrys ornata* whose females can reach 16.5 cm long.

55. *Bufo marinus* (now *Rhinella marina*), the cane toad. JGK regards the name *marina* as misleading, but cane toads can be found foraging for invertebrate prey on sea shores in the tropics.
56. Now the Natural History Museum (NHM).
57. There are now 11 described species of bichir (genus *Polypterus*). Freshwater, lunged fishes. Now regarded as stem actinopterygians (ray-finned fishes). *Lepidosiren* and *Protopterus* are two of the three genera of extant lungfish (the third is *Neoceratodus*), all lobe-finned fishes in the class Dipnoi.
58. John Samuel Budgett (1872-1904) was still an undergraduate when he accompanied JGK to Argentina in 1896. As well as helping with the *Lepidosiren* work, Budgett researched frogs: Budgett's frog *Lepidobatrachus laevis* (Family Ceratophryidae) is named after him.
59. Mal de caderas is a chronic, sometimes fatal disease of horses, occurring in South America; caused by the blood parasite *Trypanosoma equinum*, transmitted by biting flies.
60. The New Australia Cooperative Settlement Association, led by journalist William Lane, was granted land by the government of Paraguay. Several hundred settlers arrived in 1893 and 1894. Much dissent within the colony led to its dissolution, but those who wished to stay were granted individual plots of land, and around 2,000 descendants now live in Paraguay. Anne Whitehead's *Paradise Mislaid* (1997) gives a full account.
61. Kerr, J.G., editor (1907). *The work of J.S. Budgett*. Cambridge University Press. Contains Budgett's zoological papers, a biographical sketch by Shipley and work by colleagues.
62. The genus *Morpho* includes at least 29 species of large Central and South American butterflies (family Nymphalidae): wingspans up to 20 cm, mostly blue and green on the upper sides.
63. Ground sloths of the genus *Megatherium* were as large as elephants: extinct as a result of human expansion about 12,000 years ago.
64. South American genus of large armadillos, extinct by about 11,000 years ago.
65. John Stanley Gardiner (1872-1945) was a specialist on coral reef biology.
66. Sedgwick's *Student's Textbook of Zoology* was published in three volumes 1998-1909.
67. John Peile (1838-1910) promoted the higher education of women, becoming President of Newnham College, Cambridge.
68. Charles Smart Roy (1854-1897); Scottish-born pathologist.
69. Sir George Paget Thomson (1892-1975); Nobel laureate for discovery of the wave properties of the electron.
70. Sir Francis Darwin (1848-1925); third son of Charles Darwin and Emma Wedgwood. Francis worked with his father on plant movements and insectivorous plants, and edited his father's papers.
71. Henry Sidgwick (1838-1900) was a prominent utilitarian philosopher. Co-founder of Newnham College for women, his wife became its Principal.
72. Igerna Brunhilda Johnson Sollas (1877-1965), known as Hilda, was a zoologist/palaeontologist with wide interests. Published results of work extensively until 1916 when she became a Christian Scientist and gave up actual science.
73. Sir William Bate Hardy (1864-1934); biochemist and physical chemist.
74. Erskine Childers (1870-1922); writer, politician. *The Riddle in the Sands* (1903) was one of the first spy novels, and predicted war with Germany. Childers was executed during the Irish Civil war.
75. Composed in 1894 by Felix McGlenn and Monroe Rosenfeld.
76. Ernst Karl Abbé (1840-1905); German physicist and optical scientist. Working at the Carl Zeiss AG Company in Jena, perfected the optical microscope via a series of innovations in design.
77. Arthur William Rogers (1872-1946).
78. Ernst Haeckel (1934-1918); foremost German zoologist of his time: promoted Darwin's ideas on evolution. Gifted artist. Marine biologist, embryologist, eugenicist. Unlike some others, recognised the contributions of Jewish scientists and artists.
79. Max Fürbringer (1846-1920); German comparative anatomist; devised the first phylogeny of birds based on anatomical features.
80. Richard Wolfgang Semon (1859-1918); German zoologist, with strong Australian links.
81. Hermann Braus (1868-1924); German comparative anatomist; worked on the evolution of the tetrapod limb.
82. Lord Balfour was a Scottish representative peer in the House of Lords and Conservative politician. Served as Secretary of State for Scotland 1895-1903.
83. Frederick Orpen Bower (1885-1925), Regius Professor of Botany at Glasgow until 1925. The Botany building is now named after him (and was built during his tenure).
84. Edward Jeremiah Bles (1864-1926) contributed to the book on Budgett.
85. Johan Christian Fabricius (1745-1808) was a Danish zoologist and student of Linnaeus. The 18th century's foremost entomologist, he named about 10,000 species and established the basis of insect classification. The Fabrician types rescued by JGK remain in the Hunterian Zoology museum to this day. For an account of Fabricius's interactions with William Hunter, see: Hancock, E.G. (2015). The shaping role of Johan Christian Fabricius on William Hunter's insect collection and entomology. In: Hancock, E.G. *et al.* (Editors). *William Hunter's World.* pp. 151-164. Routledge, London.
86. Robert Arnot Staig (1878-1963); Scottish entomologist; acted as curator of the Hunterian Zoology museum.
87. Staig, R.A. (1931-1940, 1931). *The Fabrician Types of Insects in the Hunterian Collection at Glasgow University*. Two volumes, Cambridge University Press.

88. Thomas Henry Huxley (1825-1895); self-taught English biologist and anthropologist. Populariser and defender of Darwin's theories. Had major impact on education, including his role in the Royal Commission (1876-1878) which led to the reform of the Scottish Universities via the Universities (Scotland) Act of 1889. The emphasis of his zoological teaching on comparative anatomy to the exclusion of study of living animals is often criticised.
89. Robert Herbert Story (1835-1907) was a Scottish Church of Scotland minister and divinity academic. Principal of the University of Glasgow 1898-1907.
90. William Hunter (1718-1783); Scottish physician and anatomist. Avid collector of zoological specimens, coins, minerals etc. His collections were bequeathed to the University of Glasgow along with funds to build a museum to house them. The original museum was built to adjoin the old Glasgow College on High Street. Along with the rest of the University, the collections were moved to the Gilmorehill campus in 1870. For a discussion of the original zoological collections and their fate, see: Reilly, M. (2015). William Hunter's zoological collections. In: Hancock, E.G. *et al*. (Editors). *William Hunter's World*. pp. 135-150. Routledge, London.
91. Laurence Austine Waddell (1854-1938); Scottish physician, explorer and linguist. Spent many years in India and developed heterodox ideas on human history. Made a large collection of bird skins, many donated to the Hunterian museum in 1894, and many still in the collection.
92. The Steven family owned the extensive Bellahouston estate on the south-west side of Glasgow during much of the 19th century. On the death of Elizabeth Steven in 1892, a Trust became operational which aimed to use revenues from the estate for charitable, religious and educational purposes in greater Glasgow. The Trust is still active in 2023. £500 in 1903 would be worth about £77,500 in 2023, so, with the University matching the grant, JGK had the equivalent of £155,000 in to-day's money.
93. Sir Donald MacAllister (1854-1934); mathematician, physician and linguist (could speak 19 languages, apparently). Principal, University of Glasgow 1907-1929, then Chancellor.
94. Sir John James Burnet (1857-1938), son of architect John Burnet. J.J. Burnet was responsible for many prominent buildings in Glasgow and London.
95. The Rockefeller Foundation was founded in 1913 with a mission to find solutions to public health problems such as hookworm, malaria and yellow fever.
96. At the four ancient Scottish universities, the rector is elected every few years by the students, and is supposed to represent their interests; the Rector's formal role is to chair the university's governing body, the court. In December 1923, the recently elected Rector was the Conservative politician Frederick Edwin Smith, first Earl of Birkenhead.
97. Lockhart Muirhead (1765-1829) supervised the transfer of Hunter's collections to the University of Glasgow, and was Regius Professor of Natural History 1807-1829.
98. The last person to hold the Chair of Natural History at a Scottish University was D'Arcy Wentworth Thompson, author of *On Growth and Form* (1917) who held the St. Andrews chair 1917-1948.
99. William Forster Lanchester (1875-1953) worked on crustacean diversity.
100. Wilfred Ede Agar (1882-1951) moved to Melbourne in 1919. His work on sperm development in *Lepidosiren* was published in the *Quarterly Journal of Microscopical Science* 57, 1-44 (1911).
101. In JGK's time, the term Protozoa was used for all single-celled heterotrophic organisms, such as *Amoeba*, *Paramecium*, *Euglena* and *Trypanosoma*. Although the term is still used, the taxonomy of these organisms no longer puts them together in a single group.
102. Charles Martin (1881-1930) published a paper on the ciliated organism *Acineta papillifera* in the *Quarterly Journal of Microscopical Science* 53, 351-377 (1909).
103. John Samuel Dunkerly (1881-1930) lectured at Glasgow till 1926, then moved to Manchester as professor. A specialist on flagellate protozoa.
104. Muriel Robertson (1883-1973) was introduced to zoology during her undergraduate years at Glasgow. A Carnegie fellowship then allowed her to do fieldwork in Sri Lanka. The rest of her career was based at the Lister Institute in London where she unravelled the life cycle of the sleeping sickness parasite, *Trypanosoma gambiense*. One of the first women to be elected FRS (1947). Research on trypanosomes returned to Glasgow with the arrival of Keith Vickerman in 1970.
105. Monica Taylor (1877-1968) trained as a teacher in Liverpool, then joined the Sisters of Notre Dame as a nun and was transferred to Glasgow in 1901. With the support of JGK, she was permitted, chaperoned, to take lectures and practical classes in zoology. Awarded Glasgow D.Sc. in 1917.
106. Margaret Jepps was a lecturer 1923-1952. After retirement, she published *The Protozoa, Sarcodina* (1956), Oliver & Boyd, Edinburgh.
107. George Stuart Carter (1893-1969) lectured at Glasgow 1923-1930.
108. Agnes Eleanor ("Nora") Miller (1898-1994) lectured at Glasgow 1924-1963. She was awarded a Ph.D. for her thesis *Studies on Dipnoan Structure* in 1962.
109. JGK interacted with two of Glasgow's learned societies. He gave four lectures to the Natural History Society of Glasgow, all published in the Society's journal: two on the Hunterian zoological collections, and two on marine biological themes. He seems never to have been an office-bearer in the Society. His involvement in the Royal Philosophical Society of Glasgow was more extensive, acting as President 1925-28, and delivering six lectures on a variety of topics, all published in the Society's Proceedings.

110. Alexander Dunlop Lindsay (1879-1952); first Baron Lindsay of Birker. Professor of Moral Philosophy at Glasgow 1922-1924, later Master of Balliol, Vice-Chancellor of the University of Oxford, then first Principal of Keele University.
111. Bower, F.O., Kerr, J.G. & Agar, W.E. (1919). *Lectures on Sex and Heredity, Delivered in Glasgow 1917-18.* MacMillan and Co., London.
112. The marine organisms named in this paragraph are: a) sea pens - colonial cnidarians of the order Pennatulacea, 35 extant genera; b) seagrass - the only flowering plants growing in marine environments, about 60 species; c) *Philine* and *Akera* (or *Acera*) are genera of sea-snails; d) *Doris* and *Facelina* are genera of nudibranch gastropods; sea urchins - many species in the phylum Echinodermata; e) *Chaetopterus* is a marine polychaete, common name parchment worm; f) *Phoronis* are worm-like animals in the phylum Phoronida.
113. JGK would no doubt be delighted to learn that Loch Sween was designated a Marine Protected Area in 2014, with its population of native oysters one of its special features.
114. John Alwyne Kitching (1908-1996); professor of Biology at the University of East Anglia 1963-1974; specialist on rocky shore ecology and barnacles.
115. JGK married Elizabeth Mary in 1903; their children were Adam, Ronald and Isobel. Elizabeth Mary died in 1934. JGK then married a widow, Isabella Dunn Clapperton, in 1936.
116. Common sundew *Drosera rotundifolia*; oblong-leaved sundew *D. intermedia*; great sundew *D. anglica.*
117. Common names of food fish do not always apply to the same species: these both belong to the cod family. Saithe is *Pollachius virens*; lythe is *P. pollachius.*
118. Grey seals *Halichoerus grypus* are larger then common (or harbour) seals *Phoca vitulina.*
119. John Hammond Teacher (1869-1930); St. Mungo Professor of Pathology at Glasgow Royal Infirmary; specialist in reproductive pathology.
120. The Thomas Stevenson-built lighthouse is on an isolated basalt rock, 29 km west of Colonsay, Inner Hebrides.
121. An explanation of the green ray or green flash can be found on Wikipedia.
122. This seems to be an error: Sir Hector Clare Cameron (1843-1928) studied under Lister and progressed to be Professor of Clinical Surgery, University of Glasgow. For this 1933 recollection, perhaps JGK means Sir Hector's son, Hector Charles Cameron (1878-1958), child health specialist at Guy's Hospital, London.
123. *Janthina* is a genus of small pelagic sea snails, floating by means of bubble rafts; *Velella* is a single species of free-floating hydrozoan.
124. JGK's interest in how animals conceal themselves, and its relationship to camouflage techniques in warfare, is a major theme later: see Notes 180 and 183.
125. James Fairlie Gemmill (1867-1926); Ayrshire-born physician and biologist. Lectured at the University of Glasgow in surgery and embryology until 1916. From 1919, Professor of Natural History at University College Dundee. His book on natural history in the poems of Robert Burns was published posthumously (1928).
126. David Robertson (1806-1896); from the age of eight, worked as a herd boy in Ayrshire, but progressed to a medical degree at the University of Glasgow. Studied the fauna and flora of the Isle of Cumbrae, especially the marine life. He died before the opening of the marine station. His second wife Hannah joined him in his researches and, after his death, became a marine biologist in her own right. *The Ark* was towed by Murray's steam-yacht *The Medusa* through the Forth and Clyde canal and then down the Clyde estuary to the Isle of Cumbrae.
127. The third Marquess of Bute (1847-1900); the Crichton-Stuart family are landowners of Arran, Bute and Cumbrae, and, through marriage, of extensive lands in south Wales. The gothic revival style Mount Stuart House was built 1879-1900 at his direction.
128. This work was eventually published as Chumley, J. (1918). *The Fauna of the Clyde Sea Area.* Glasgow University Press. It collated the records of Murray and colleagues from 1884 to 1892. Chumley later joined the Glasgow Zoology staff.
129. The Rothesay Royal Aquarium opened in 1875-6. After its period of use as a laboratory, it became a swimming pool. This was now the fourth Marquess.
130. Sir John Sankey led a commission into the future of the U.K. coal-mining industry, and recommended its nationalisation. This was rejected by the government. Nationalisation would have affected the Marquess's income from the South Wales coalfield.
131. Laurence Pullar (1838-1926); Scottish businessman, geographer and philanthropist. Helped fund the *Challenger* expedition (1872-1876) and also the surveys of Scottish lochs published as Murray, J., Pullar, L. & Chumley, J. (1910). *Bathymetrical Survey of the Scottish Fresh-water Lochs. Volumes 1-6.* Challenger Office, Edinburgh. It covered 562 lochs and took 10 years to complete.
132. Dr Sheina Macalister Marshall (1896-1977) was a zoology graduate of the University of Glasgow. Worked on plankton, especially copepods, at Millport throughout her long career. The second of JGK's female students to be elected FRS (in 1963).
133. Andrew Picken Orr (1898-1962), a chemistry graduate, worked with Sheina Marshall, including joining the Great Barrier Reef expedition (1928-1929) led by Maurice Yonge, later Regius Professor of Zoology at Glasgow.
134. Ernest William MacBride (1866-1940); Irish biologist who specialised in the morphology and evolution of echinoderms.
135. JGK gives a more detailed account of the Millport story in Kerr, J.G. (1949). The Scottish Marine Biological Association. *Notes and Records, the Royal Society Journal of the History of Science* 7, 81-96.

136. John Ferguson (1838-1916) left his huge library (18,000 volumes), much of it on alchemy, to the University as the Ferguson Collection.
137. James Moir (1840-1915); authority on feudal law.
138. Sir Thomas McCall Anderson (1836-1908); Professor of the Practice of Medicine.
139. Cooper (1846-1922); Professor of Ecclesiastical History, served as first chaplain of the University's Officer Training Corps.
140. Sir William Macewen (1848-1924) was one of the most innovative surgeons of his time, using Lister's antiseptic techniques and also the new method of anaesthesia. Pioneer of brain surgery. Served as Surgeon-General to the Royal Navy in World War 1, hence his uniform. Helped found the Erskine Hospital for damaged soldiers.
141. Constantin Levaditi (1874-1953) was a Romanian microbiologist who worked for most of his career at the Intitut Pasteur in Paris. Researcher on viral diseases and on syphilis, including developing a staining method to identify spirochaetes.
142. Sir Hugh Seymour Walpole (1884-1941) was a prolific writer of novels and memoirs. *The Secret City* derived from his experiences working for the British Government in Russia during World War 1; he left just before the revolution.
143. Sir Hugh Shaw-Stewart (1854-1942); Scottish politician, soldier, landowner.
144. Alan Clapperton (1888-1931) trained as a lawyer. On his early death, his widow became JGK's second wife.
145. Dudley Julius Medley (1861-1953); specialist in constitutional history.
146. Sir Richard Burdon Haldane (1856-1928); Scottish philosopher and politician, brother of physiologist J.S. Haldane, and uncle of geneticist J.B.S Haldane. Responsible for major reforms of the army as Secretary of State for War in the Liberal government.
147. First Baron Lister (1827-1912); surgeon best known for pioneering antiseptic techniques, much of his research being done at Glasgow Royal Infirmary.
148. James Watt (1736-1819); Scottish inventor, engineer, chemist; best known for improvements to the steam engine.
149. Ramsay MacDonald (1866-1937); Scottish Labour Party politician, twice Prime Minister in the inter-war years.
150. Sir Lewis Shedden (1870-1941) was Unionist party organiser in Glasgow.
151. Sir Henry Mechan (1856-1943) was an engineer, philanthropist, and champion of public health education. He endowed the University of Glasgow chair named after him.
152. Stanley Baldwin (1867-1947) was U.K. Prime Minister three times in the inter-war years.
153. Since 1603, Parliament included members voted for by graduates of the universities (who therefore could have two votes). The system was abolished in 1950. From 1918-1950, graduates of the four ancient Scottish universities were represented by three MPs.
154. Thomas Alexander Harvie Anderson (1872-1953); a lawyer involved in many aspects of Scottish affairs, including Erskine Hospital.
155. John Buchan (1875-1940); Scottish politician and statesman, best known now for his novels, written in his spare time, the best remembered being *The Thirty-nine Steps.* MP for the Scottish Universities 1927-1935, then appointed Governor General of Canada and ennobled as Lord Tweedsmuir.
156. £1,450 in 1935 is equivalent to about £132,000 in 2023.
157. Archibald Joseph Cronin (1896-1981); Scottish physician and writer. Studied medicine at Glasgow 1914-19. His novel *Country Doctor* was the prototype for the TV series *Dr Finlay's Casebook*.
158. Naomi Mitchison née Haldane (1897-1989); prolific writer of mainly historical novels, and political activist. A biologist early in her career, like others in the family, and two of her children became professors of biological subjects.
159. John Viriamu Jones (1856-1901); Welsh scientist, first Principal of Cardiff University.
160. Leifchild Stratton Leif-Jones, Lord Rhayader (1862-1938); temperance movement leader and Liberal politician.
161. Henry Margesson (1890-1965); first Viscount Margesson; Conservative Politician best known in his role as chief whip.
162. Noel Skelton (1880-1935); Scottish journalist and politician, MP for the Scottish Universities 1931-35.
163. Walter Elliot (1888-1958); Scottish Unionist politician. Studied science, then medicine at the University of Glasgow. Moved to politics after World War 1 and served in several government ministries.
164. Douglas Jamieson (1880-1952); Scottish lawyer and Unionist politician. Left parliament to become a judge as Lord Jamieson.
165. John Allsebrook Simon (1873-1954); first Viscount Simon. Began as a Liberal, but was later a Conservative. He was among only three people to have occupied the three high offices of Home Secretary, Foreign Secretary and Chancellor of the Exchequer (as well as being Lord Chancellor).
166. James Maxton (1885-1946); Scottish socialist politician. MP for Glasgow Bridgeton 1922-46, and leader of the Independent Labour Party.
167. Edward Alfred Minchin (1866-1915); Jodrell Professor of Zoology at University College London. Proved that sponges are not coelenterates, and studied trypanosomes.
168. John Anderson (1882-1958); first Viscount Waverley and MP for the Scottish Universities 1938-1950.
169. Edward Gibbon (1737-1794); English historian and politician: remembered for his massive *The History of the Decline and Fall of the Roman Empire*.
170. Sir Francis Fremantle (1872-1943); physician and Conservative politician.
171. Sir Alfred Bakewell Howitt (1879-1954); physician and Conservative politician.

172. Sir Ernest Graham-Little (1867-1950); dermatologist, and MP for London University 1924-1950.
173. Sir John Wardlaw-Milne (1879-1967); Conservative politician.
174. Sir James Young Simpson (1811-1870); Scottish obstetrician; first physician to demonstrate the anaesthetic properties and use of chloroform.
175. Edward Jenner (1749-1823); pioneer of vaccination.
176. Sir Patrick Manson (1844-1922); Scottish physician and parasitologist. First to demonstrate mosquitoes as vectors of a parasitic infection (filariasis).
177. Robert Fulton (1765-1815); American engineer and inventor. Credited for first commercially successful steamboat in the U.S.A.
178. Palmerston as Prime Minister was worried that the Suez canal would disturb the political balance between Russia, the Ottoman Empire and the U.K.
179. Sir William Grahame Greene (1857-1950); English civil servant; permanent secretary to the Admiralty in World War 1.
180. Abbott Handerson Thayer (1849-1921); American artist, naturalist and teacher, with his son Gerome, published *Concealing Coloration in the Animal Kingdom* (1909). Considered a pioneer of camouflage, though he mistakenly believed all animal coloration has concealment as its function.
181. Sir Edward Bagnall Poulton (1856-1943); English evolutionary biologist; Professor at Oxford; coined the term aposematism (warning coloration), and wrote *The Colours of Animals* (1890).
182. Norman Wilkinson (1878-1971); artist specialising in marine paintings.
183. Hugh Bamford Cott (1900-1987); British zoologist and artist. Worked as lecturer at University of Glasgow (1932-1938), and was awarded D.Sc. by the University for his thesis on frog coloration. Moved to Cambridge 1938, and worked as a camouflage expert in Africa during World War 2. Published *Adaptive Coloration in Animals* (Methuen, 1940) illustrated mainly by his own pen and ink drawings. The full story of Kerr, Wilkinson, Cott and the government's policies on camouflage has been told by Peter Forbes (2009) *Dazzled and Deceived: Mimicry and Camouflage* (Yale University Press, 2009). See also Ruxton, G.D., Allen, W.L., Sherratt, T.N. & Speed, M.P. (2018). *Avoiding Attack: the Evolutionary Ecology of Crypsis, Warning Signs and Mimicry*. (2nd edition). Oxford University Press.
184. Sir Howard Kingsley Wood (1881-1944); Conservative politician, Minister for Air and Chancellor of the Exchequer.
185. Sir John Greer Dill (1881-1944); Chief of the General Staff in World War 2.
186. Lord Robertson (1896-1974) was military governor of Germany after World War 2.
187. Sir Charles Galton Darwin (1887-1962); English physicist; Director of the National Physical Laboratory and Master of Christ's College; worked on the Manhattan Project. Grandson of Charles Darwin.

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Doc Flo's 1917 Lecture Notes on Protozoa

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ABSTRACT

Flora MacDonald (née Livingstone) was a first-year medical student in 1917 when she attended John Graham Kerr's lectures in zoology, starting with the protozoans. She made a clearly written, illustrated set of notes which remained among her papers for decades until their recent discovery by her descendants. The notes give an account of the state of knowledge of protozoa and other disease organisms at a time when many life cycles and transmission routes were being worked out, and some time before viruses could be visualised. Here we present a typed-up version of Flora's notes, a short biography of her by descendant Alasdair Whyte and a commentary on the state of knowledge demonstrated through the notes by protozoologist and medical educator Stephen Phillips.

EDITORIAL INTRODUCTION

This section is the result of a fortuitous interaction between zoology lecturer Anna McGregor and Celtic/Gaelic lecturer Alasdair Whyte. They are collaborating on a community development project related to the West Highlands oyster fishery. In conversation, Anna mentioned the Graham Kerr centenary events, and Alasdair revealed that his great grandmother Flora had been a Glasgow medical student. His family had recently discovered a jotter containing Flora's lecture notes from the start of her studies: would we like to see them? Alasdair made a scan from the jotter's original pages, and sent it to Roger Downie. The scan showed 125 clearly written pages, accompanied by many labelled drawings (Fig. 1). The notes cover the first 18 of Graham Kerr's lectures in the autumn of 1917, with the first 13 devoted to protozoans, mainly those of medical importance. The jotter is unlikely to contain precisely what Flora wrote down during the lectures: everything is so neat. More likely, as a conscientious student, Flora would have written up the jotter from the rough notes taken earlier in the day. Nathan Miller skilfully typed up the notes, and these are reproduced here, minus the drawings. Protozoologist Stephen Phillips, who lectured to the medical students of the 1970s to 1990s, kindly agreed to write a commentary on the notes. Alasdair Whyte wrote a short biographical note on his great grandmother, and Doc Flo's family has kindly allowed us to use the lecture notes and her story in this publication.

The notes provide a fascinating glimpse of what was taught to medical (and science) students about protozoa early in the 20th century: Stephen Phillips's commentary brings out the excitement of that time when much was being discovered about disease and its causation, and also summarises some of the advances since that time. We wonder how many other sets of early lecture notes remain hidden in attics.

DOC FLO: A BIOGRAPHICAL NOTE

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Dr Flora Livingstone MacDonald M.B.E., M.B., Ch.B. (1899–1982), my great-grandmother, graduated from the University of Glasgow in 1923 (Fig. 2). It is fair to say that medicine was in her blood. Dr Flora's maiden name – Nic an Lèigh in the original Gaelic (Livingstone in the anglicised form) – literally means "daughter of the physician". The Gaelic term lèigh is related to the English term leech. The clan, Clann an Lèigh, is a sept of the Beaton clan: hereditary physicians to the MacDonald Lords of the Isles.

Family lore holds that Dr Flora – or Doc Flo as she is still known on her native island of Muile (Mull) – was a keen scholar from an early age. One summer's day, she was sitting on a bridge over Abhainn Bhà (River Bà) near her childhood family home in Grùilinn (Gruline) when some well-to-do visitors enquired quizzically what picture-book the young girl was reading. "It's not a picture-book", replied young Flora politely, "it's Latin".

Young Flora's Latin reading would have stood her in good stead when she arrived at the University of Glasgow at 9 a.m. on 15th October 1917 for the first zoology lecture of her medical degree with Professor Graham Kerr. It was while the family was clearing the loft of Flora's family home – most recently the home of her eldest daughter, Mairi, my granny, and Cameron, my grampa – that we came across Doc Flo's jotter containing her immaculate lecture notes and illustrations from Professor Kerr's lectures.

After graduating in 1923, Dr Flora practised from An Sàilean (Salen) in Mull with her husband, Dr Reginald MacDonald, until Dr Reggie's death in 1953. Several

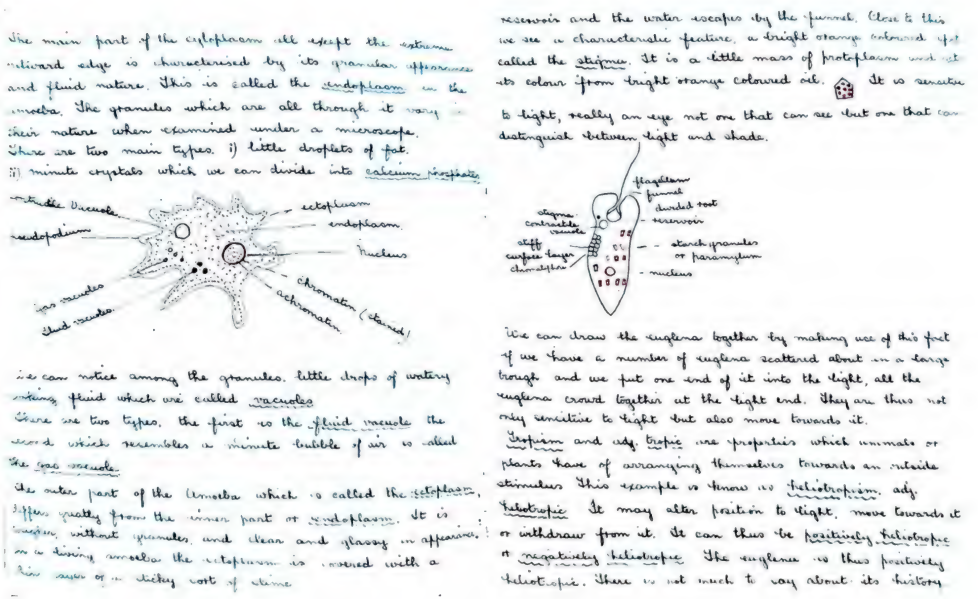

Fig. 1. Two pages from Flora's lecture notes. On the left, a page from lecture 1 on *Amoeba proteus*; on the right, a page from lecture 6 on *Euglena*.

Fig. 2. Flora in her graduation gown and carrying her graduation scroll. (Photo: A.C. Whyte family archive)

stories from that time, including tales of Doc Flo's daring dashes through the hills of Mull on her motorbike in response to medical emergencies, are still in circulation locally. Perhaps the most famous of these stories, though, relates to her actions on 1st to 2nd February 1945 when she was involved, along with several others, in the rescue of the crew of a plane which crashed on her native island. The plane was a Dakota KK194 which had taken off from Dorval near Montreal and crashed into Beinn Tealladh (Beinn Talaidh) in central Mull. Despite cutting her leg and being pulled out of waist-deep icy water in conditions described as "the most severe in living memory", Doc Flo led one of the rescue parties. The five occupants of the plane who had survived the impact were brought to safety. In October 1945, Dr Flora was awarded an M.B.E. for her part in the rescue.

Dr Flora and Dr Reginald had five children: Ian, Bill, Robin, Mairi and Mabel. Ian, the eldest, was in the second year of a medical degree at the University of Glasgow at the outbreak of WWII. He joined the R.A.F. and lost his life in April 1945. Robin worked for British Telecom, later BT, and lives in An t-Òban (Oban). Bill was a G.P. in Cinn Tìre (Kintyre). Mairi, my granny, and Mabel, who helped to write this piece, qualified as Registered General Nurses. Mabel met her husband, Roger Cannon, a medical graduate from the University of Glasgow, in Glasgow Royal Infirmary. Ian Cannon, Roger and Mabel's son, is also a University of Glasgow medical graduate. Roger and Ian practised together from Kirkintilloch for six months before Roger's retiral in September 1996. Ian retired from General Practice in March 2023.

DOC FLO'S LECTURE NOTES: COMMENTARY

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Introduction

As part of the celebrations to mark the Centenary of the opening of the Graham Kerr Building in 2024 I have been asked to cast my eyes over Doc Flo's "Zoology" notes from 13 lectures given by Professor Graham Kerr. My main qualification for doing so is that I taught and then was, for many years, Tutor-in-Charge of a two-term first year biology course given to medical and dental students when they started at the university. In the 1990s, entry qualifications for medicine changed, students were required to have taken Higher or A level Biology before coming into medicine which coincided with the introduction of "problem-based learning" in medicine, and an introductory biology course was no longer required.

Commentary

The first thing to note is that Doc Flo's notes were written in ink. My introduction to writing at primary school was with a simple ink nib and a desk ink well: a recipe for spilt ink and a mess. The pens seconded as darts. Fountain pens were invented in the 1880s and became popular in the 1920s up to the 1950s when affordable ballpoint pens became available: fountain pens could be considered messy to use and inconvenient. Is it likely that Doc Flo used a simple nib and an ink well? The notes have very few corrections and are sprinkled with ink drawn illustrations. She writes in full sentences rather than the key words and phrases which I noted down when I attended undergraduate lectures at University College London: possibly she made notes during the lecture and then wrote these up in more detail later in the day at her leisure. Her handwriting is clear and legible. In my days teaching first year classes, it was always said that when you went into the lecture theatre to give a lecture to a first-year biology class and said "Good morning" they responded with a verbal "Good morning". A first-year medical student would write down "Good morning".

Biological knowledge has expanded at an ever-increasing rate over the 100 years since Professor Kerr gave these lectures, as has the technology available for biological investigation. Perhaps this is best illustrated by Doc Flo's reference to the "invisible germs" which are the cause of infantile paralysis (polio) and dengue fever, although it was well known then that the latter was mosquito-transmitted, as she writes. The assumption that the former was also insect transmitted was not the case as we now know but is transmitted by the faecal/oral route or person to person transmission. The "invisible germs" or "filterable agents" became known as viruses and became visible with the invention of the electron microscope in the 1930s.

Three lectures on *Amoeba proteus* in the start of the course was an introduction to "the lowest form of life" and the structure and physiology of the cell before the advent of the electron microscope and an understanding of subcellular structures. Doc Flo reports Kerr's view on protoplasm, "the physical basis of life", that if we divide it into its parts for analysis, we will take away its most important qualities "and also life itself". This pessimistic view of developing an understanding of the molecular basis of life would soon be superseded, with work such as that of Szent-Gyorgi and Krebs in the 1930s on how cells process energy via the tricarboxylic acid cycle. Doc Flo would have seen *A. proteus* down the monocular compound microscope: the practical laboratory in the Graham Kerr Building, opened after Doc Flo graduated, had large windows to allow sufficient light in to illuminate the specimen viewed down the microscope. She writes that "under high power an amoeba with no nucleus cannot creep", suggesting her notes include the lectures and observations made in the practical classes. "Its living activity is controlled and governed by the nucleus" she writes. The fourth lecture covers the medically important amoeba causing amoebic dysentery - *Entamoeba histolytica* - and how to distinguish it from the harmless *E. coli*, information the modern medical student would be given but not the rest of the lecture on the Foraminifera, Heliozoa and other relatives of *A. proteus*. Let us remember that David Livingstone of this parish is reputed to have died in 1873 at the age of 60 in present day Zambia from a combination of amoebic dysentery and malaria, just 44 years before Doc Flo was learning about the parasitic protozoans.

Lecture 5 on the megalospheric type of amoebae and their complex life cycles would not be included in a medical student's curriculum today. At the end of this lecture is a list of the different types of protozoans which included the spirochaetes which we now know are bacteria. The next two lectures go into the detail of the flagellates with a detailed consideration of *Euglena* and then the colonial flagellate *Volvox*. These led into a lecture on what Doc Flo called "a family of deadly microbes", the genus *Trypanosoma*, in the lecture entitled "Parasitic germs of disease". Her illustrative example is *T. gambiense*, one of the causes of African sleeping sickness, which is very appropriate as this was the subject of the research of one of Graham Kerr's students, Muriel Robertson. Muriel Robertson first worked on reptilian trypanosomes in Sri Lanka 1907-1910, and then, as a member of the Lister Institute, spent three years in Uganda where there was a serious outbreak of sleeping sickness, working on *T. gambiense* and made major discoveries of the life cycle of the parasite in its human and insect host (tsetse fly – *Glossina* spp.). Half a century later, after Muriel Robertson and Doc Flo, the late Keith Vickerman, a past Regius Professor of Zoology in Glasgow, would describe the fine structure of the parasite and relate it to the life cycle described by Doc Flo in her notes from Graham Kerr's lectures. Doc Flo describes the relapsing nature of the human infection in the patient's blood which we now know reflects the parasite's ability to

undergo antigenic variation. Antigenic variation became a major focus of research at Glasgow University 50 years later and still continues. Doc Flo's notes on the variety of trypanosome species and their recent (to her) history, make interesting reading.

Lecture 9 starts with *T. cruzi* which had only been discovered eight years previously in the kissing bug (subfamily Triatominae) in Brazil, and is the cause of Chagas disease in South and Central America. Chagas disease is named after Carlos Chagas, a Brazilian physician and researcher who, on 14th April 1909, diagnosed the disease in a person for the first time. Lecture 9 continues with reference to *Leishmania* spp., named after another Glasgow graduate, William Leishman, who in 1901 discovered *L. donovani* in a post-mortem spleen specimen of a patient who had died from kala azar, or visceral leishmaniasis. Leishman published his findings in 1903. After leishmania her lectures reach the Sporozoa, which Doc Flo describes as a group "with great practical importance". As with me 50 years later in my undergraduate introduction to the Sporozoa, Doc Flo describes in detail the life cycle of the gregarine *Monocystis*, a common sporozoan found in the earthworm, *Lumbricus*. I wonder how many medical students today know the life cycle of *Monocystis*, or even of its existence.

Lectures 10 and 11 tell her about malaria and what was known then about human malaria parasites, the details of the clinical infections and what was known of the life cycle. She recounts the historical landmarks of the discovery of the malaria parasite by Laveran in the blood of a soldier with malaria, the role of Ronald Ross, another Scot, in 1898, in demonstrating the role of the mosquito, *Anopheles*, in the transmission of the parasite. She makes reference to the Italians, Grassi and colleagues, who confirmed the role of the mosquito in transmitting human malaria and who tried to take the credit for Ross's discovery. Doc Flo was clearly on the side of Ross in the celebrated dispute between Grassi and Ross. That there was a cycle in the liver in the mammalian malarias was not demonstrated until 1948 by Shortt and Garnham at the London School of Hygiene and Tropical Medicine (as we know it today).

Lecture 11 moves onto other Sporozoa including the tick-transmitted piroplasms, and in particular *Babesia bigemina* and *Theileria*. Finally, reference is made to Myxosporidia in fish and Microsporodia, mainly in insects, and the role of *Nosema bombyx* as an obligate intracellular parasite infecting *Bombyx mori* to cause pebrine disease in silkworms. This was first discovered by Louis Pasteur, and was the start of the "germ theory of disease". *Nosema* also infects bees. I can see no reference to *Toxoplasma gondii*, the ubiquitous sporozoan in almost all warm-blooded creatures, with a sexual cycle in felids. Its importance as a disease of people was not demonstrated until the late 1930s. In 1908, while working at the Pasteur Institute in Tunis, Charles Nicolle and Louis Manceaux discovered the parasite in the tissues of a hamster-like rodent known as the gundi (family Ctenodactylidae). The sexual cycle was demonstrated by the late Bill Hutcheson working at the University of Strathclyde.

Lecture 12, still entitled "Parasites", ranges from Sarcosporidia (*Sarcocystis* spp.), mostly a parasite of cattle, through an introduction to free living ciliates, such as *Paramecium* and *Vorticella*, and concluding with extensive reference to the spirochaetes which we know as bacteria, rather than protozoans. Doc Flo tells us their place is uncertain between "animals and plants". The importance of spirochaetes is seen in human diseases such as relapsing fever, transmitted by ticks and lice, and yaws and syphilis. As a medical practitioner, after qualification, Doc Flo would be familiar with syphilis and that treatment was not easy before the discovery of antibiotics, 20 years after she would have qualified.

Lecture 13 moves onto diseases, mostly caused by "invisible germs" or "filterable agents" which we know as viruses, such as dengue fever, sand-fly fever, small-pox, hydrophobia (rabies) and scarlet fever (a bacterium *Streptococcus*). There is mention of infantile paralysis (polio) which was thought then to have an insect vector. This lecture reminds us how much the discovery of antibiotics and the development of additional vaccines has transformed the work of a GP. She discusses the fact that some protozoan parasites and their hosts have evolved together, the hosts become "tolerant" and do not cause disease, while in other "susceptible" hosts infection can be disastrous. In 1917, Doc Flo notes that malaria or "ague", which was common in the U.K., has practically "died out" but there was a risk that soldiers returning from the (First World) war would bring malaria back and infect "English" mosquitoes. This, indeed, proved to be the case when soldiers infected with malaria were placed in demob camps in East Anglia, and from whom local *Anopheles* were infected and transmitted malaria to locals in East Anglia.

The remaining lectures in the recovered papers from Lecture 14 on 1st November, 1917, to Lecture 18 on 4th November, 1917 (not printed in this volume), progressed Doc Flo's knowledge from the protozoa to the simplest metazoan, *Hydra*, recognising two layers of cells, and cellular differentiation, through increasingly complex members of the Cnidaria (coelenterates) ending up with detailed structure and life history of corals, and concluding with the sponges, suggesting that there are more notes which have been lost with time.

With the passage of time within any subject in any discipline, the volume of knowledge expands relentlessly and choices have to be made as to what is essential knowledge to progress a student to the point when they have a sufficient grounding and practical experience to become a member of their chosen profession. In the case of the current medical students, I would guess that the only part of Doc Flo's notes which would be included in their lectures are the lectures on parasitology. I had a distinct advantage when I lectured to the first year medical students in that I gave them their introduction to parasites, and if you could not grab the

attention of an eager medical student with an illustrated lecture on a particularly gruesome parasite you were in the wrong profession. Some three weeks ago I had an occasion through a shared voluntary activity to meet a senior member of the medical profession who had studied medicine at Glasgow and had been in my first-year class. Having established who he thought I was, albeit decades older in appearance, he went on to say "I remember the lecture you gave on the guinea worm and winding the adult worm around a stick"... Success!!

JOHN GRAHAM KERR'S LECTURES ON PROTOZOA, AS RECORDED BY FLORA LIVINGSTONE, 1917

Lecture 1 *Amoeba proteus* 15th October 1917, 9-10 a.m.

The *Amoeba proteus* belongs to the lowest form of animal life. While all other creatures have gone through a process known as evolution, the amoeba has retained its original form. It is a little blob in that mixture called protoplasm which is the physical basis of life. We cannot determine the structure of protoplasm for if we divide it into its component parts for the purpose of analysis, we will find that we have taken away all the most important parts and also the life itself.

The dead remains of protoplasm

It is composed of a mixture of proteins which are again compounds of certain elements - carbon, oxygen, hydrogen, nitrogen and sulphur. Proportion – C52, O23, H4, N16, S2. The creature is composed of molecules the nature of which chemists cannot inform us. We can only use simple observation through a microscope in examining this creature.

Description: The amoeba is about half a millimetre in diameter. It is of absolutely irregular shape and there are endless varieties. It has when alive many rounded projections.

We can divide it into two distinct parts, a protoplasm rounded in shape called the nucleus and the remainder known as the cytoplasm.

The main part of the cytoplasm, all except the extreme outward edge, is characterised by its granular appearance and fluid nature. This is called the endoplasm in the amoeba. The granules which are all through it vary in their nature when examined under a microscope. There are two main types: i) Little droplets of fat; ii) Minute crystals which we can divide into calcium phosphates.

We can notice among the granules little drops of watery looking fluid which are called vacuoles. There are two types. The first is the fluid vacuole, the second, which resembles a minute bubble of air, is called the gas vacuole.

The outer part of the amoeba which is called the ectoplasm differs greatly from the inner part or endoplasm. It is tougher without granules and clear and glassy in appearance. In a living amoeba the ectoplasm is covered with a thin layer of a sticky sort of slime.

The nucleus has not the granular appearance of the rest, but it has a curious mottled look which is due to the fact that it is composed of two different materials. i.e. proteins which moreover has the addition of a considerable amount of phosphorus. If we kill an amoeba and dye or stain it, the nucleus takes on the stain in a certain way. Certain parts stand out distinctly while other parts between remain unchanged. The coloured portion is called the chromatin because it stains so readily while the unchanged portion is called the achromatin. There is usually only one nucleus in an amoeba but in some varieties there are more.

Physiology of the amoeba

Hitherto we have been considering the anatomy of the amoeba to study, to which life is not necessary. But we cannot study physiology except on a living body.

Its movement: The amoeba is in a state of continual movement. It is of a characteristic kind and is called the amoeboid movement. Bits of the surface push out to form projecting pieces called pseudopodia. They are rounded finger shaped lobes and are sometimes called lobopods. As it pushes forward, the endoplasm flows in a stream out to the end of the pseudopodium. The ectoplasm disappears and the endoplasm extends right to the point. If the ectoplasm is absent when forward movement ceases, the endoplasm becomes ectoplasm. These therefore are not fundamentally different. The ectoplasm is a portion of the cytoplasm which has taken on certain characteristics through its contact with water. We may find a peculiar type of amoeba which has a peculiarly blunt pseudopodium. In this the endoplasm twists through the ectoplasm and presently we have a big mass of the endoplasm outside the creature which loses its granular appearance and becomes ectoplasm; while pieces of ectoplasm shut off from the water turn into endoplasm.

Formation of pseudopodia

These push out more actively on one side than another and by them the amoeba gradually creeps along. It goes about an inch per day or 1mm per hour. It can only creep when its body is covered by the slime. Like the slug it makes a slimy path for itself. If it cannot form this slime, it may push out its pseudopodia in an aimless way but cannot travel.

The contractile vacuole: Has a sort of pulsation like the beating of the heart. We called this contraction and expansion systole and diastole. This vacuole is on the side opposite to the amoeba's line of travel. It appears like a fluid vacuole, but it increases in size and in 5-8 minutes it may be as big as the nucleus, then suddenly it vanishes. If we place some Indian ink in the water, we will notice that when the vacuole disappears the particles of ink are pushed out. In reality, it opens to the outside and pumps its fluid out. This cycle takes place every 5-8 min. It has two main functions. It pumps out watery fluid from the cytoplasm. Water is always soaking into the protoplasm, it accumulates and is then

passed out. The amoeba is thus constantly being flushed out with water, accomplishing two things: breathing or respiration and excretion.

Lecture 2 *Amoeba proteus* 16th Oct 1917
The amoeba feeding
We call taking food into the cytoplasm ingestion. The amoeba feeds upon plant organisms which are round shaped and microscopic. It goes up to one and pushes pseudopodia on each side of the organism and presently we find the plant is completely surrounded by the protoplasm of the amoeba.

The plant organism is now contained in a food vacuole. As water is also taken in, this forms a vacuole round the organism. The form of food may not be a large organism but tiny bacteria in the water. The watery fluid passed out by the contractile vacuole has a remarkable property called agglutination. It secretes agglutinate which has the power of making the bacteria form into solid lumps and thus they can ingest the solid mass. This is called the process of agglutination. An amoeba may feed on a different material, minute water plants in the form of delicate films. It creeps up to the film and surrounds a piece of it and it can exercise in some curious way a pull on the film and a little later we would see the film getting curled up inside the amoeba until it is all coiled up into a food vacuole.

What happens to the ingested food
If it is alive, for a little while it will move about trying to escape, but gradually the movements slacken and finally we find the organism is dead. If we apply a test to the amoeba, we will find the fluid in the vacuole is strongly acid. The cytoplasm has secreted this acid and then passed it into the cavity of the food vacuole. Its function is to kill the food organism.

The process of digestion
Digestion never affects living protoplasm, it must first be killed. We will notice that the outline of the food particle becomes blurred and indistinct. What really happens is that the cellulose wall round it becomes destroyed. Next, changes take place in the colour. It was at first bright green through the presence of chlorophyll, the colouring of all plants. It becomes darker then it gets a yellowish tinge, next yellow, then reddish, then browny and finally a dark reddish brown.

3rd step
The protoplasm of the food organism breaks up. This is called the process of disintegration. The dead remains of protoplasm are made up of proteins. This complicated mixture is now breaking up into comparatively simpler subjects. The object is to make the protoplasm so that it can be absorbed by the living protoplasm of the amoeba. Before they can absorb and use other protoplasm, it has to be broken into simpler compounds. If an amoeba met an amoeba, one would think it has its food ready-made but no. Living protoplasm cannot add living protoplasm to itself without it going through the aforesaid process. Then only can it absorb the simpler compounds and make new stuff for itself.

How this breaking up is brought about
It is brought about by the actions of ferments or enzymes. These bodies are protein in their nature but the curious fact is that they possess the remarkable power of causing or hastening chemical change in substances with which they come in contact, and it is remarkable that there are an enormous number of them and each can only change some particular type and always in the same way. The secretion of a digestive ferment or enzyme is powered by the amoeba into the food vacuole and the effect is the disintegration of the food organism.

By chemical tests during the period of actual digestion, the chemical reaction is found to be no longer acid but strongly alkaline. This indicates that we have at work a digestive ferment of the same type as in the human being, known as the tryptic ferment. The food particle undergoes this process of digestion, the amoeba absorbs all of the simpler substances that can be made use of. The useless parts remain in the food vacuole as so much debris or faecal material. Then when this stage the food vacuole rises to the surface, touches it and twists to the exterior and the granules of faecal matter are left in a little heap. Though the food vacuole is full of digestive ferment it does not damage the amoeba because it is alive. If we dissect a freshly killed rabbit and open it up, its parts are at first in a normal state but in two hours or so the walls of the stomach disintegrate; as soon as it is composed of dead protoplasm, the digestive ferments get to work on it.

The amoeba goes on feeding and increases in size, showing the process of growth. Its condition would soon because impossible, however, if it grew and grew. Its surface is very important for by the surface it takes in water and oxygen and as it grows bigger its surface will become relatively less, i.e. it will increase at a lesser rate than the bulk. We saw how cytoplasm is comparatively liquid and thus it would be quite impossible for the amoeba to keep its shape. It would flow out into a shapeless mass in which life would be quite impossible. Nature however always provides a corrective process to the process of growth. This is provided by a process known as the process of fission, a simple reproductive process. The first thing is that a change comes over the nucleus.

Process of fission
If we stain the nucleus of an amoeba about to undergo fission, we will find that the chromatin is no longer evenly distributed. It collects in little pods known as chromosomes. These are seen to arrange themselves somewhere about the centre of the nucleus while the chromatin takes on a curious thread-like appearance all running in longitudinal lines. Later it will be seen to have changed its shape. The chromatin is much longer and the chromosomes have divided into two and the two sets have retreated from each other. This long double spindle nips across the middle and the two halves round themselves off and the chromatin returns to its normal shape and we have two ordinary nuclei. This is known as mitosis or karyokinesis. The amoeba becomes elongated more and more until it is like a dumbbell. The

isthmus becomes narrower and narrower and finally snaps and soon we have two amoebas.

Thus the amoeba counteracts too rapid growth and this is the simplest form of reproduction. We can add to our knowledge by the experimental method. We simply make a change in the surroundings of the creature and note what happens. We must first take care that when we make a change it must not be too violent, or the amoeba dies. The change must be very slight.

Mechanical Stimulus: First we can make a living amoeba respond to a mechanical stimulus. If we prod it with a needle the amoeba will creep away from the needle. Thus we know it is sensitive.

Chemical stimulus: There is another kind of amoeba called the *Amoeba limax* on account of its slug-like look. It has a single pseudopodium which it places in front. If we add a minute trace of alkali to a drop of water with an *Amoeba limax* in it, it forms a number of pseudopodia in the form of a number of long threads. One would now think it was an *Amoeba radiosa*.

It (*limax*) gives up its own characteristic appearance and takes on the characteristic of another species. If the water is warmed the amoeba becomes more active, but at 30°C you find continuation of this activity disappears. Movements are sluggish and it soon dies. Lower temperatures cause it to become sluggish but do no apparent harm. Thus it is sensitive to change of temperature.

It is sensitive to light. If light shines up from below a slide with a dark patch on it and an amoeba is placed on the patch, it draws back whenever a part of it comes into the light. Their natural surroundings are in darkness because they live in the mud and debris at the bottom of ponds.

Lecture 3 *Amoeba proteus* 17th Oct 1917
Effect of electricity on the amoeba
If we take a drop of water containing amoeba and run a weak current of electricity through it, the amoeba at once changes its form. It is no longer like an *Amoeba proteus*, it has taken on the characteristics of an *Amoeba limax* and still more it creeps steadily in one direction, that is towards the negative pole. The two poles, negative and positive, are known as the cathode and the anode. If the current is rapidly reversed, the amoeba at once turns and goes the other way.

Effect of radium
If a piece of radium is placed near the water, the amoeba draws in all its pseudopodia. It takes on a spherical shape and if the radium remains longer near it, the protoplasm breaks down and the amoeba dies. Emanations from radium are hurtful to all living substances. Certain diseases such as malignant tumours are treated by radium, for the diseased cells are affected more easily and are destroyed before the healthy cells have time to get damaged.

Merotomy: This is an experiment. We divide a large amoeba into two by pressing on it with a needle. It usually happens that the nucleus slips to one side and the result is that we have two amoebas, one with a nucleus and the other merely cytoplasm. The one with the nucleus goes on existing as a perfectly normal amoeba: creeps, takes in food and digests it as usual, but there is one important change – the nucleus undergoes a gradually shrinking inside until it is in proportion to the rest of the amoeba. This brings out a general principle all through the animal kingdom. There is more or less a definite proportion between the nucleus and the cytoplasm. It is believed in certain disease conditions that the trouble is due to the loss of proportion between nucleus and cytoplasm. This affects the cytoplasm in a harmful way.

The amoeba without the nucleus: This amoeba is different from the other. It cannot creep but it pushes out its pseudopodia in an aimless way. Under high power we can see the reason, it has lost the power of producing the slime. You may also see it take in a particle of food. It takes it into the food vacuole but it remains undigested. The non-nucleated amoeba has lost the power of producing the digestive ferment. It is thus abnormal in its behaviour. Its activities become slowed down and in about a week it dies.

The chief details of interest are that the amoeba gives us an idea of a cell. A cell is a piece of protoplasm containing a single nucleus. The special interest is that the amoeba has only one cell, while the higher animals begin life as a single cell but do not remain so, they undergo fission many times. The great difference is that when an amoeba undergoes fission, the two amoebas go off independently in different directions. The animal cells undergo fission but remain together. This goes on many thousands of times and finally we have a huge body all united together.

The second interest: is that the amoeba has brought out an important point in the physiology of a cell. Its living activity is controlled and governed by the nucleus. If this is removed or becomes diseased or abnormal, the creature becomes helpless and dies. The study of movement brings us into touch with certain things. The most conspicuous movement, amoeboid movement, consists of pushing out pseudopodia. We can produce this movement artificially. Take a small quantity of rancid oils and put into slightly alkaline water and shake up. This is an emulsion. A drop of this placed under a cover slip shows us in many cases little droplets which do not remain circular but push out little pseudopodia from different parts. A droplet may travel for quite a long distance. The interesting point is we know the reason. Of two fluids, one inside another which do not mix, one becomes spherical in shape. In physics we call this surface tension. The surface later is in a state of tension like a small india-rubber balloon. A softened piece of the balloon would bulge out and become a sort of pseudopodium. The alkali outside diminishes the surface tension in various places and this forms pseudopodia. The living amoeba goes on in precisely the

same manner. The surface tension of the protoplasm is reduced, and the pseudopodia bulge out. We do not know however what diminishes the surface tension. We can also produce more complex movements artificially, such as the drawing in of a vegetable filament. We place some drops of chloroform in water and also some fine threads of shellac. If one of the chloroform drops touches the shellac it goes round it and spreads over the surface. It stretches out at the points where it touches the thread and we see there is a pulling action at work and soon the shellac filament is drawn into the centre of the drop. It is in fact ingested by the drop. This is another case of surface tension. The tension at the points of contact tends to draw in the filament.

Feeding and digestion of food in the amoeba: The great principle is this - whenever living substance is in a state of normal being, it takes into itself simpler dead substances and builds them up into new living protoplasm. But we saw that there was another process. The production of waste material, calcium phosphate and carbon dioxide. This is the breaking down of living material into simpler unliving substances. We get these two processes at work whenever there is life. This is called metabolism. The moment we try to study it, it stops so we cannot tell what it is. There are two other terms. The building up is called anabolism and the breaking down is called catabolism. We very often find these two phases practically balance one another but not always. Anabolism is sometimes predominant, then we get the phenomenon of growth. When catabolism predominates, the creature shrinks in size. But we don't always get this shrinkage because very often we get the products, instead of being thrown out, retained and stored up inside the body of the creature.

Another important point about the feeding: Ordinary green plants feed upon extremely simple chemical substances. They get nitrogen from simple substances, the various nitrates or the carbon from the air, carbon dioxide, CO_2. They divide this, let go the oxygen and use the carbon. An amoeba can't do this, we can't keep an amoeba going on nitrates and carbon dioxide, it must have protein material ready formed. The ultimate effect is that animal life is dependant on vegetable life because the plants make complex proteins from simple substances.

One more point: It is an absolute characteristic of metabolism that it involves the process of oxidation. The amoeba requires a constant supply of oxygen and as it rises it combines this oxygen with carbon in catabolism, which passes away in carbon dioxide. This is the same as the process of combustion. Carbon and oxygen together combine suddenly and produce heat. There is a slow process of combustion going on the whole time. It goes on quick enough in higher animals to warm the body until the temperature is much higher than surrounding objects. The amoeba has no noticeable temperature, but no doubt if we possessed a fine enough instrument, we would discover probably that it had a tiny temperature.

There are different kinds of amoeba, different species. We must be careful how we use the word 'species'. A group like cats and tigers is called a genus *Felis*. The different species have their own special name. *Felis leo* the lion, *Felis onca* the jaguar. Each is a distinct species. This is absolutely necessary because the popular names of animals are different in various countries. *Amoeba* is a genus and there are different species, i.e. *Amoeba proteus*, *Amoeba limax*, *Amoeba radiosa* etc. The important practical point is that certain species have taken on a parasitic form in the bodies of men or animals. One harmless parasite, the parasitic amoeba, is split up into a special genus called *Entamoeba*. The commonest is called *Entamoeba buccalis*. It is often found in the mouth among the teeth but is quite harmless.

Lecture 4 Parasitic amoebas 18th Oct 1917

Many of the parasitic forms of the amoeba are to be found in the intestines. It was not until 1903 that their importance was discovered. Schaudinn found that there were two different types of parasite. *Entamoeba coli*, a harmless little creature and *Entamoeba histolytica* or *tetragena*, a very dangerous parasite. It is the cause of the dangerous disease dysentery. This type is called amoebic dysentery to distinguish it from that caused by bacteria. This amoeba also causes another disease, liver abscess, a usually fatal, tropical disease.

Characteristics of E. histolytica: We must be able to distinguish this type from the harmless *E. coli*. This is a small amoeba, *E. coli* is larger. Therefore we judge by measurement. The unit is 1/1000 mm, known technically by the Greek letter Mu (μ). The amoeba's average size is 20-30μ in diameter. One of the most characteristic points is the way it moves. It has a single large pseudopodium which it pushes out in front and it moves in jerks. The pseudopodium is composed of pure ectoplasm.

When the patient is affected, these parasites burrow into the walls of the intestine, feed upon them, particularly on the red corpuscles of the blood. The result is that, as a rule, we find in the endoplasm the remains of the corpuscles. This is an infallible proof of the *E. histolytica*.

When the patient is recovering, the amoebas change. They leave the walls and creep about inside the cavity of the intestine. They alter in appearance. They are smaller, 12-16μ. The nucleus is larger in proportion. The endoplasm is full of vacuoles and the food particles are no longer corpuscles but little particles of debris they pick up in the intestine. This may go on for months, but as time goes on another change comes over the amoebas. They round off into a spherical shape (11-14μ diameter). They surround themselves all over their surface with a thin skin or shell, known as a cyst. It is a protective device. The amoebas pass away to the exterior and are easily damaged. They are easily destroyed by drought but if the encysted amoeba falls on moist ground or into water, it goes on living for a long period. When a new individual takes in these cysts in drinking water, they at

once start dysentery. They come out of the cyst, creep about and burrow into the intestinal walls. They multiply rapidly by fission and start a typical case. The cyst is 11-14μ in diameter. *E. coli* has also an encysted stage but it measures 15μ. If in doubt as to species, measure a number in order to obtain average.

An additional help in identification: When the amoeba is in the encysted stage the nucleus divides. *E. histolytica* divides twice and shows four nuclei. *E. coli* divides four times and shows eight nuclei. Thus, we see the amoeba is of great importance in relation to medicine. It is also important in relation to agriculture.

It has often been found that a soil normally extremely fertile suddenly loses its fertility. Chemically examined, it is as rich as ever but the agriculturalist says "it has turned sick". Green plants require to get their nitrogen supplied in the form of nitrates which are formed by bacteria called nitrifying bacteria. When a soil turns sick, it is due to a tremendous increase of amoebas and similar creatures which keep down the supply of bacteria and prevent the forming of sufficient nitrates. We have a striking bit of evidence, a sample of soil is baked or treated with chloroform, which kills the amoebas but not the bacteria. We now find the soil has lost its sickness and is quite fertile again.

We divide the animal kingdom into subdivisions called phyla. The division in which the amoeba is we call protozoa. The first animals belong to this class. The amoeba belongs to the first subdivision, Sarcodina, which are formed of a little mass of protoplasm which has no definite shape and is soft all over its surface. We find they feed and move by means of pseudopodia and are characterised by softness and pushing out of their surface. The subdivision of Sarcodina is into two types known under the heading Rhizopoda. The first group is Amoebea which includes the genus *Amoeba* and other forms such as *Arcella* and *Difflugia*. These differ from amoeba in having a shell dome shaped in the *Arcella* composed of horny matter secreted by the protoplasm. On the concave side there is an opening through which the pseudopodia come out. As it is burdened with this shell, it is apt to fall and would be unable to right itself were it not for the fact that it can form gas vacuoles. A capsized one will form these on one side only, these buoy it up and give it a decided tilt until it can finally touch the ground with its pseudopodia and thus right itself. *Difflugia* has a shell but of a very different kind. Instead of a continuous horny substance it is made of grains of sand, which the creature ingests and passes out on to the surface, on which there is a sticky sort of cement in which they form the shell. The other group is the Foraminifera, to which belongs the common marine form *Polystomella*.

Main features of Polystomella: It is common on our own coasts creeping about on the seaweed. In its living condition it is a round disc-shaped organism and all around it are numerous pseudopodia quite unlike those of the amoeba, being thin threads. These are not always separate. Sometimes they fuse together and form a network. It has a skeleton in the form of a shell composed of calcium carbonate. In order to examine the creature, we have to dissolve the shell with corrosive sublimate and acetic acid. Then we can examine it. The protoplasm has a very curious and typical appearance. The whole creature is composed of pieces of protoplasm. The successive pieces are joined together at their inner ends. These segments live in successive chambers and they are filled with the mass. It is just ordinary looking protoplasm. This is not confined to the cavities. The wall of the chambers is perforated with myriads of little holes or Foramina, through which the protoplasm extends and forms a layer in the outside of the shell. This is called the external layer. It is this that extends out to form the pseudopodia. A common mistake is to imagine that the pseudopodia came out through the little holes in the shell.

The pseudopodia of the Polystomella: are used, not only for movement, but also for feeding. If it comes to a plant the pseudopodia stick to it and there are active flowing movements from the body to the pseudopodia. The particle is soon surrounded by a mass where it is digested. The products flow back to the body. There is a continual flowing of protoplasm back and forward along the pseudopodia. If we examine a number of *Polystomella*, we will find they are not all the same, there are two distinct types. The difference is seen particularly in the middle part. In one, the large sphere of protoplasm in the centre is found to be 60-100μ in diameter. In the other the centre is only 10μ. From this difference they derive their names. The first is the megalospheric type, the second the microspheric type. The formation of the second chamber is different. The chamber in the latter goes off into a horn like projection, the other is round.

If we stain two specimens, we find a difference in the nuclei. In the first this is always present about the centre of the mass that is in the spiral. It is in the middle of the bulk of protoplasm. The nuclear material is not confined to the nucleus. If we stain the specimen we find shreds of chromatin scattered through the whole protoplasm, namely nuclear material lying outside the nucleus. These are called chromidia. Thus it has a principal nucleus and in addition chromidia. A stained microspheric type is different. It has no big nucleus but a number of small nuclei scattered about.

If we examine a large number of *Polystomella*, we will find about 30 megalospheric to one microspheric. We find the meaning of this curious fact in the life history of the creature. The micropsheric after a time reproduces by fission, not into two organisms but into many. This is known as schizogony. In this process the pseudopodia seem to become more numerous, increase in size and presently the whole cytoplasm has crept out of the shell into the surrounding waters and taken the place of the pseudopodia. If we stain the specimen we will find that the nuclei have broken up and there are only chromidia left. Later we find new nuclei have made their appearance. The chromidia have become condensed to form these new nuclei. When this comes about, the

cytoplasm begins to show signs of breaking up. It divides up and we have now an empty shell and in its neighbourhood, pieces of its cytoplasm which are rounded off. Each piece has a nucleus and chromidia, slender pseudopodia and is able to creep. Each surrounds itself with a thin shell. The microspheric has given rise, through schizogony, to myriads of new ones. They are about 60-100μ in diameter. Another clue to their identity, the protoplasm begins to bulge out and gives rise to a second cell joined to the first. This second rounded piece is really the beginning of a young megalospheric.

Lecture 5 Megalospheric type 19th Oct 1917

The megalospheric also reproduces but in a very different way. The chromidia undergo a great increase in number. The protoplasm is full of it while the large nucleus breaks down and disappears, probably into chromidia. A very large number of small round nuclei make their appearance, probably formed by the chromidia. The cytoplasm concentrates round these small nuclei, so that the whole substance is divided into these little pieces of protoplasm each containing a little nucleus. We will notice a curious quivering movement throughout the whole *Polystomella* and then a swarm of minute individuals make their way out. Each consists of a little rounded bit of protoplasm with a nucleus. These can swim with great rapidity. They have no pseudopodia, but instead they have two thread-like projections called flagella. These are quite different from pseudopodia. They can be bent rapidly backwards and by their lashing movement they swim. These are really protoplasmic threads. If we saw this process, we would see the creatures swimming away. If they wander about they soon die, but if there was another *Polystomella* undergoing fission in the same waters, each pair of individuals - one from each *Polystomella* – would undergo a process of fusion together. Their cytoplasm as well as the two nuclei would become as one creature.

The flagella disappears and this new individual remains motionless for a time. By measurement, we might obtain a clue, it measures 10μ. This is the centre portion of a new microspheric individual. It soon buds off again and again until it is a characteristic microspheric.

The important thing, fusion, is found all through the animal kingdom. The cells that undergo fusion are what are known as gametes. The cell formed by their fusion is called a zygote. The process is known as syngamy.

This *Polystomella* example of foraminifera has a special characteristic in its shell or skeleton, a kind of horny material or flinty or siliceous material, or solid grains of sand, but in the great majority of cases, calcium carbonate. The characteristic pseudopodia are long and thread-like and have a tendency to become fused with one another. Another great characteristic feature is the dimorphism, i.e. division into the two types, megalospheric and microspheric.

These foraminifera are marine, some creep about on seaweed on mud or on rocks, but not in fresh water. A vast number are called pelagic. They inhabit the open sea, drift about in the waters and form what is called the plankton or drifting population of the sea. This term is only applied to those carried hither and thither by the water. In many parts we find these very numerous, untold myriads floating about. Individuals are continually dying and sinking down. When alive, they float freely because they are always forming vacuoles full of fluid jelly substance, lighter than water. In certain parts, particularly in warm places, there is a continual rain of dead bodies from the surface to the depths. They sink very slowly, in fact take years in deep water. The limy skeleton undergoes a process of solution, it dissolves gradually in the sea water. In the deepest parts they are dissolved long before they can reach the bottom. In parts not so deep, the shells reach the bottom, accumulate, they no longer dissolve because there are no currents, and the water is completely saturated with calcium carbonate. Thus, the shells no longer dissolve. In these ocean parts we have a great deposit of foraminifera ooze. This is a greyish ooze, sometimes called globigerina ooze: from another species which also lives among the polystomellas. One day this ooze will form rock composed entirely of foraminifera shell. In past times, in the old genealogical periods, this process also went on and in the course of ages, turned into rock made of chalk. If we broke up real chalk and examined it under the microscope, we would find it was made up mostly of foraminifera shells. It was concluded that chalk had been formed at great depths because near the shore the ordinary mud from the rivers etc. would prevent this process taking effect. However, when it was investigated, it was found the foraminifera in chalk are closely allied to the modern ones found in shallow water. Thus we concluded, the chalk was formed in comparatively shallow water. There is a peculiar limestone in Egypt, on the shores of the Mediterranean and goes in a band from Persia through Asia to Japan. This is called nummulite limestone because it is composed of curious flat discs shaped like coins. When examined, these are really shells full of chambers much larger than those of the *Polystomella*. If we examined sections we would find some were megalospheric and some microspheric.

In another subdivision come the Actinopoda, characterised by the fact that their pseudopodia are stiff, project stiffly from surface like spines. These are again subdivided into Heliozoa of which a particular example is the *Actinosphaerium*. This creature lives in fresh water and when looked at under the low power, it is approximately spherical in shape. Its pseudopodia are thin and tapering, it resembles a sun and is thus called the Heliozoa or sun animalcule.

If we examine it under a higher power, we see that the cytoplasm contains an enormous number of vacuoles, spongy in character because of their being filled with fluid. The vacuoles are arranged round the surface of the creature in a row. These are larger than the inner vacuoles and this is its ectoplasm. The endoplasm constitutes all the rest of the creature which is full of

much smaller vacuoles. The ectoplasm is prolonged out into pseudopodia, each of which is a long tapering structure, fairly stiff. Under very high power we see that the stiffness is due to the fact that up the centre there is a rod like structure called the axial filament. It supports and gives stiffness. It goes down as far as the edge of the endoplasm.

It uses these pseudopodia for feeding not for moving. If an organism comes up against one, it becomes paralyzed. There seems to be a poison about them. The organism sticks on pseudopodium and the neighbouring ones lean over and become attached to it. They gradually thicken and shorten and gradually as they shorten, the animal is pulled down and is ingested in a food vacuole, like in an amoeba. If we watch this, we see an interesting detail as the pseudopodia shorten, the axial filament vanishes completely. It has become resolved into ordinary protoplasm. Although it looks so distinct, it is not really a thing by itself but just a piece of protoplasm which has undergone a temporary modification like the ectoplasm and endoplasm of the amoeba, not due to the fundamental difference but changes through circumstances.

The endoplasm is nucleated, a large number from one to several thousands. There are contractile vacuoles, we see a bit of the surface bulging out and then collapsing. This is an example of Actinopoda and subdivision Heliozoa. Its essential characteristics are: First, it is a freshwater creature, Second, it has an axial filament in pseudopodia. Sometimes there is a siliceous skeleton, but not in the *Actinosphaerium*.

Another interesting group allied to this is called Radiolaria, differing in habit inasmuch that it is marine instead of freshwater.

Radiolaria type-features: It is spherical in shape more than the former and it has a simple nucleus about the centre. It is very characteristic. Cytoplasm is divided into two distinct regions separated by a membrane which has large openings. It is called the central capsule. It is pretty granular, full of cytoplasm. Outside is another mass differing in the fact that it is full of vacuoles. They contain a watery jelly which buoys up the creature. They are pelagic and float on the ocean.

The outer protoplasm extends into pseudopodia, radiating like those of Heliozoa. This differs as a rule in having no axial filament and also the individuals are apt to get fused together. This tendency is very slight and not like foraminifera. Then we come to the most characteristic point. The outer protoplasm secretes just below the surface a layer of glassy transparent silica. There are breaks in it and thus it forms a perforated shell. After it has formed a skeleton, it goes on growing, becomes larger. The protoplasm extends beyond skeleton and in a short time a second skeleton may be formed. This may be repeated until we have a series of concentric spheres. They assume all sorts of wonderful shapes and are most beautiful things. The interesting points in physiology are that in the outer protoplasm with vacuoles, dotted about are little round bodies. If they are stained each has a nucleus, yellowish green colour. These are little plants of a particular genus called Zooxanthella which live in protoplasm. We must now remember how to distinguish between this type symbiosis and the parasites. Parasiticism is applied to creatures living on another. A creature is called a parasite when the living is entirely to the advantage of one individual, i.e. the parasite. When it is mutual, when each helps the other, they are in symbiosis. These cells produce oxygen and this is of great advantage to Radiolaria (Table 1).

Lecture 6 Flagellata - *Euglena, Volvox* 22nd Oct 1917

The second main division of Protozoa is known as Flagellata. They swim by means of flagella. This is a quite regular thing all through their life. It includes in its species the most deadly microbes and that makes it doubly interesting.

Euglena: This is a fairly common freshwater creature and when in large numbers, gives that bright green colour we see on the top of ponds. This colour is due to chlorophyll. The shape is like a spindle. It swims actively by means of a long flagellum which projects from the blunt end. To make out the details, we require to magnify very highly. We will notice it is composed of a mass of protoplasm. There are no distinct divisions (ectoplasm and endoplasm). The surface later is rather denser and stiffer than the rest. This gives it a more or less definite shape. Close to the blunt end the surface turns inwards forming a depression called a funnel. This opens into a chambe r called the reservoir. A flagellum

I.	Sarcodina
	(A) Rhizopoda
	(1) Amoebea – *Amoeba*, *Arcella difflugia*
	(2) Foraminifera – *Polystomella* (megalospheric and microspheric)
	(B) Actinopoda
	(1) Heliozoa – *Actinosphaerium*
	(2) Radiolaria
II.	Flagellata – *Euglena*, *Volvox*, *Trypanosoma*
III.	Sporozoa – *Monocystis, Plasmodium*
IV.	Ciliata – *Paramecium* (Holotricha), *Vorticella* (Peritricha), *Stentor*, *Stylonchia* (Hypotricha)
V.	Suctoria - *Acimeta*
VI.	Spirochaeta

Table 1. Divisions of Phylum Protozoa.

proceeds from this and if we follow it to its base, it divides. These branches are on the inner sides of the funnel. The creature is green in colour, it gets this from germs called chromatophore. These in *Euglena* are rather rounded discs of protoplasm packed together close to the surface. There is a large rounded nucleus situated towards the pointed end of the creature. The contractile vacuole lies close to the reservoir between it and the surface. It bursts inwards into the reservoir and the water escapes by the funnel. Close to this we see a characteristic feature, a bright orange coloured spot called the stigma. It is a little mass of protoplasm and gets its colour from bright orange coloured oil. It is sensitive to light, really an eye, not one that can see but one that can distinguish between light and shade.

We can draw the *Euglena* together by making use of this fact. If we have a number of *Euglena* scattered about in a large trough and we put one end of it into the light, all the *Euglena* crowd together at the light end. They are thus not only sensitive to light, but also move towards it.

Tropism (adj. tropic): properties which animals or plants have of arranging themselves towards an outside stimulus. This example is known as heliotropism (adj. heliotropic). It may alter position to light, move towards it or withdraw from it. It can thus be positively heliotropic or negatively heliotropic. The *Euglena* is thus positively heliotropic. There is not much to say about its history. If the euglenas are kept in favourable surroundings, they undergo fission in a longitudinal direction and finally split in two. When conditions are unfavourable, it encysts. It surrounds itself with a protective cyst of a jelly like material. We often find fission taking place while *Euglena* is in a cyst in a condition of rest. Other times it undergoes fission while swimming about. We often get a characteristic appearance of this. They divide over and over again in the cyst and each makes a new cyst for itself. This extends the original cyst until it is of enormous size. If we examine the thick green scum on a pond, we will find it is composed of them. They do not ingest particles of food but feed like green plants. This mode of nutrition is called holophytic. It is able to build up protein out of comparatively simple chemical materials. Particularly it is able to build up starch-like materials through the activity of its chlorophyll under the influence of light. When we examine euglenas that have been under a bright light, we will see all through the protoplasm bright shining glassy looking rods. They are composed of a substance called paramylum, in reality grains of starch. Chemically it is like ordinary vegetable starch, a little different from animal starch. This is produced by the action of light on the chlorophyll. In the case of extended cysts, the giving off of oxygen causes bubbles and makes them float. We must note an interesting point. The *Euglena* is not absolutely holophytic. If we take two glass jars full of euglenas, keep both equally in the light, and to one jar add some organic material, a few drops of animal or vegetable matter, the euglenas will be found to flourish more than those in the other jar. They will increase more rapidly and are generally better in every way. Thus to a certain extent, the *Euglena* can absorb food material through its surface in solution. The last point to notice in the physiology is its movement. There are two distinct types of movements. One is the ordinary swimming movement in a very characteristic fashion. It stretches flagella out straight and the tip twirls round with a screw like motion. The body is thus towed along. The second type is so characteristic that it is called euglenoid movement. This is seen in a stationary *Euglena*. Its body swells out at one end. This swollen portion gradually travels back to the end. Thus, it goes through a sort of writhing movement.

Volvox: This is a freshwater creature, it lives in ponds and lakes. It has an appearance never to be mistaken. A small sphere which rolls along. It goes through the water in a certain direction and rotates along at the same time at right angles to its course. A student told the examiner "The *Volvox* is a creature which goes at right angles to its line of travel". Yet this Irishism is correct.

The first thing we see is that it is composed not of a single cell, but commonly about 10,000 cells, which under low power show as little green dots in the wall. Under very high power we find each cell is oval shaped. A little mass of protoplasm. At outer or broad end the protoplasm extends itself through the surface into two fine threads and it is by means of these flagella that the volvox as a whole is carried along. In the centre we see the nucleus and a pair of contractile vacuoles which contract alternately.

The creature is green in colour but the chlorophyll, instead of being contained in chromatophore, there is a large chromatophore which sheathes the whole creature but top end. The *Volvox* is thus composed of many cells which have a slender bridge between them. There is an orange red stigma present at one side of cell. These stigma are well developed in one hemisphere only, the part in front as the creature moves. They are also only at one end and this particular side is again the one that goes in front. Thus all the so-called eyes look forward. The individual cell is encysted, it has round itself a layer of transparent jelly or cyst, like the sphere as a whole. Each individual is really embedded in a cyst or jelly of its own which comes in contact with the cyst of neighbour. The outlines are difficult to distinguish but each has a hexagonal shape.

Life History: If we start a *Volvox* in favourable water, it will reproduce in a characteristic fashion. In the hinder hemisphere there are a certain number of cell individuals, considerably larger than the rest, connected to each other by several threads called parthenogonidia. There are as many as 35 of these cells in one *Volvox* colony. A noticeable point is that only 8 out of the 35 become functionally reproductive. What happens is they gradually increase in size, undergo a process of fission and divide into two. Then each divides again, making four cells, again into eight cells. A plate or rather saucer-like arrangement is formed. As they go on dividing, the rim curls inwards and eventually becomes a sphere. We have now a sphere with thousands of cells. Each individual cell sets to work to form a jelly-like cyst. The

result is they get pushed apart and the sphere undergoes an enormous increase in size and eventually we find it is a young *Volvox*. Each cell has flagella. Swimming motion begins and it breaks away from the parent and starts life independently. This mode of reproduction goes on for months creating large numbers of colonies. Then a new reproductive process begins, induced by unfavourable conditions such as the coming of autumn. In this new process, gametes are produced which are not exactly alike. One is very small, very active and is called a microgamete. The other is larger, non-motile and is called a macrogamete or egg. This is the first differentiation of the two sexes, for the macrogamete is female and the microgamete male.

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The cells which give rise to gametes are called gametocytes. First, we will look at the male colonies. In a young male colony, what seem to be cells are really microgametocytes. These are like ordinary cells and take on a yellowish-brown colour. They undergo fission into two, four, eight, etc. and eventually form an almost flattened saucer shaped plate of cells which have a long spindle shape. Each cell becomes a microgamete. When developed it is elongated in form and within are all the details of structure as in ordinary cell. At one end are longer and more powerful flagella. In centre, there is a nucleus and a particularly well-developed stigma. There is a chromatophore and a pair of contractile vacuoles at one side. This mass of microgametes move in a colony, soon break out and separate, swimming away in different directions.

The eggs of macrogametes: These look just like the parthenogonidia. They consist of a spherical cell which grows larger and larger. It becomes dark in colour and if a section is made we see that the cytoplasm has become loaded up with reserve protein forming yolk – reserve food material stored in an egg – All we can see in the way of change. A process of syngamy takes place. A microgamete comes across a macrogamete and burrows into it thus fusing with it. We have now a zygote or fertilised egg. This single cell is formed by two separate gametes. The zygote is very like a macrogamete. We can distinguish by this point – after syngamy the cell forms round it a clear protective cyst. These processes come about when external conditions are unfavourable such as cold weather or drought. As the unfavourable conditions continue, *Volvox* colonies are killed and disintegrate but the zygotes drop to the bottom and lie in the mud all through the winter or dry season. They then wake up and become active. They leave the cyst and divide like parthenogonidia until we have a new colony. One important point – In ordinary protozoa, the individual was a single cell. In course of time fission gave rise to two independent cells which were distinct new individuals, each of one cell. In the *Volvox* we have a new type of a higher order, it does not consist of one cell but a colony of cells which have undergone fission but remain together and co-operate to form an individual. The *Volvox* foreshadows more complex animals. Ordinarily we seldom think of life without also thinking of death. Both seem necessarily to follow each other but *Volvox* teaches us the inaccuracy of this. In the later part of the life history, we saw that a particular part of a whole individual became converted into gametes. Thus the living substance does not die a natural death because through syngamy it is given a new lease of life. The living substance is not necessarily mortal, it is potentially immortal. The substance goes on living indefinitely. The living substance of the gametes agrees with the whole substance of protozoa. *Polystomella* does not really die. The microspherics divide and go on living as well as the megalospheric, provided of course that they undergo syngamy. Thus, we see death is not inseparable with life. All the earliest types did not die, they went on living in other forms. Of course, a lot die accidentally. Sexual colonies produce gametes, the rest necessarily die. We have thus the phenomenon of natural death. The division of this higher order of individuals is as follows. There is the gonad or immortal cells and the larger portion composed of soma or mortal cells. We have also in Volvox, appearance of sexuality. The division into two types – microgamete (male) and macrogamete (egg or female).

The next group coming under heading Flagellata are a family of deadly microbes, Genus *Trypanosoma*.

Structure and character of a trypanosome

This microbe was first seen in 1841 by Valentin, living in the blood of an ordinary trout. In 1843 the name was given by Gruby to a similar creature in the blood of a frog. Various people came across them and paid little attention to them, until it became apparent that they were not rare but very common and caused serious diseases. Tremendous research gives us its structure and life history. It is thrown into bends or folds and swims like an eel. When fixed, it retains this shape.

It is composed of a soft mass of protoplasm with no distinct dimensions. The surface layer is a little stiffer than the rest. It is rather pointed at one end. It has a long flagellum which has a curious feature, it does not begin in the pointed end but at the blunt end. It passes along the edge and is joined to the body like membrane, like a fin or frill like arrangement. The creature swims by movement of this apparatus and proceeds in the same way as *Euglena*, i.e. follows flagellum. The extreme characteristic is the nuclear apparatus. It is divided into two portions. About the middle of the body is a big nucleus called the trophonucleus, which controls and superintends metabolism of the creature. It has a very characteristic structure. Chromatin in centre called karyosome and radiating out are small threads of chromatin which swell out at the end into little pieces.

This is only one part because the trypanosome has another nucleus, either round or rod shaped near the blunt end. This is called the kinetonucleus because it is believed to govern the movement. Close to this is a very small part which stains very deeply called the basal granule. It is connected with the end of the flagellum at the root.

There is sometimes at the broad end a distinct vacuole.

This creature reproduces by fission longitudinally and is like *Euglena*. In the process the various parts divide in a very definite order. First, the basal granule divides into two and apparently also the flagellum. We say apparently because although it has the appearance of splitting, extending right along, we don't know if there is a break or not.

Some people think it is a new one sprouting, probably however it is splitting. After the granule the kinetonucleus divides, then the trophonucleus and finally the whole protoplasmic body. These trypanosomes are typically blood parasites and swim and wriggle in the blood. The way we locate them is by noticing how the blood corpuscles are knocked about. Look for this movement to find the germ. They live in the blood of vertebrates, from the fishes up to man and they are spread from one to another by the bite of a blood sucking animal such as flies and bugs. In the case of fishes, it is done by leeches. The agent does not do this is a mechanical way, drawing a mouthful of infected blood from one person and squirting it into another like a hypodermic syringe. It is more complicated a matter. The trypanosome undergoes a special phase of its life history in the transmitting agent. First part of life in the blood of a vertebrate. The other in the body of an agent. As an example, we cannot do better than take the germ which causes sleeping sickness, *Trypanosoma gambiense*, which was examined carefully by Miss Robertson, a former student in G.U. It is found in the blood of a human being. In an infected individual the trypanosomes live in the blood and increase in number. If we take drops of blood and examine day by day, we find they increase and diminish, increase and diminish, in a sort of cycle. They reproduce by fission and if we examine blood during one of these periods, we will find the trypanosomes not only increase in number but undergo a change in form. In particular, there appear among them many individuals which differ in this very elongated shape, they are of a long slender type. Here and there among them are short stumpy ones. An important point is that it is only when stumpy ones are present that the blood can infect a blood sucking fly. If it sucks in only the slender ones, these are killed and ingested but the short ones infect the fly. They go on living and in a certain proportion of cases infect it with the parasites. The particular type of fly which becomes infected is of the genus *Glossina* and is called the *Glossina palpalis* or Tsetse Fly. With any ordinary fly nothing happens. The process is this – the short stumpy type, when taken into the alimentary canal, i.e. the stomach and intestines, become very active and undergo rapid processes of fission until the whole intestine is a seething mass of trypanosomes. Then in a week or so, from the 8th-18th day after the fly has fed, you find long slender ones make their appearance. These become more and more numerous and presently they work forwards into the stomach of the fly. Some of them go still further into the salivary glands where we find them on the 16th-30th day. In these glands these long slender ones multiply rapidly under fission and the trypanosomes produced differ from the ordinary type. They are of the *Crithidium* type resembling another creature *Crithidium* in the positions of the two nuclei. In the ordinary creature kinetonucleus was at the blunt end on the side of the trypanosome away from point. Crithidial type.

Presently we find many have the appearance of short stumpy ones, the same as those originally swallowed. Only now is the Tsetse Fly able to infect. As it bites the saliva is injected into the wound and with it is carried the germs. These proceed to multiply rapidly in the blood and soon the individual is stricken with sleeping sickness.

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Mode of infection of T. gambiense (continued): The special point to notice is that between the time that it is taken in by fly and the injection into a new being, a definite cycle takes place. There is another possible type of infection that takes place without this cycle. When the fly bites an infected individual, the proboscis become contaminated with the affected blood and some trypanosomes may stick to it. In such a case it is quite possible if fly bit someone else soon after, the germs would be introduced directly into the blood. Thus, there are two great types of infection with regards to germs spread by a blood sucking insect.

The types are (i) cyclical and (ii) direct. The type in which germs undergo a part of their life history in a second host is the cyclical. The type in which germs are injected directly into the blood from the contaminated proboscis is the direct. It is important to distinguish the two types. The first is the one of practical importance because direct infection is theoretically possible and sometimes takes place but is comparatively rare (Table 2).

Trypanosoma	**Host 1**	**Host 2**
T. brucei (Nagana)	Horse, Ox, etc.	*Glossina morsitans*
T. evansi (Surra)	Horse, Camel, etc.	*Stomoxys? Tabanus?*
T. equinum (Mal-de-Caderas)	Horse, etc.	?
T. equiperdum (Dourine)	Horse	------
T. lewisi	Rat	Rat flea
~~	~~~~~~~~~~~~~~~~~~~~	~~~~~~~~~~~~~~~~~~~~
T. gambiense	Man	*Glossina palpalis*
T. rhodesiense	Man	*Glossina morsitans*
T. cruzi	Man	*Conorhinus* (Benchuca)

Table 2. Trypanosomes and their hosts.

1. T. brucei: This is named after Bruce, its discoverer. It is the germ of a disease common to domesticated animals called the tsetse fly disease. The native of Africa call it Nagana. It has been known ever since the first days of the African explorers. As far as Zululand there are tracts of country called fly belts. If horses, mules, donkeys or oxen are taken into these tracts they are all certain to die. The early explorers learned from the natives that the death was associated with the bite of a particular type of fly called tsetse or *Glossina morsitans*. In these belts this type was abundant and the animals contracted the disease Nagana. At first, the fly was supposed to be very poisonous and the poison caused death, but in 1895 David Bruce investigated the disease and he was able to find out the real cause. He found that the tsetse, before it could cause the disease in an animal, must first have bitten a diseased animal. It is not in itself poisonous, but it carries poison from infected animals and inoculates the healthy. More than this, it must bite the second individual within two or three days. Thus, the poison it carries only remains potent for a short time, which suggests a living microbe which could only live that time. Bruce sought for a living microbe and he discovered that infected blood was swarming with *T. brucei*. In medicine these diseases are called Trypanosomiasis. Since this discovery, we got to know still more in particular, not only that there is direct infection in the first two or three days, but after the eleventh day it again becomes infectious. It has now developed cyclical infection which remains with it permanently. The details of the life history have not yet been discovered.

2. T. evansi: This germ causes a disease among horses and camels called Surra and it is particularly common in India, although sometimes found in Asia and Arabia. It is caused by a trypanosome, but it is not quite clear what insect carries the germs. Two insects are suspected – *Stomoxys*, which is rather like a house fly in appearance but it bites. It is characterised by biting proboscis. The other is a horse fly of the Genus *Tabanus*.

3. T. equinum: This germ is the cause of a destructive disease of horses in South America called Mal-de-Caderas. When an epidemic sweeps over the country it usually exterminates every horse. It is produced by a trypanosome but so far the carrier is unknown. It has been noticed that the epidemic will come to a stock farm, right to the fence and come no further. Thus it is most improbable that the carrier is a fly.

4. T. equiperdum: This germ causes a disease in horses, particularly in breeding ones. The disease is called Dourine. It is common round the shores of the Mediterranean and it differs in that it is a contagious disease and not an infectious one. The germ is spread by contact.

5. T. lewisi: This germ is common in rats, particularly in the young ones. The adults seem to develop a sort of immunity to the disease. The carrier is the rat flea. When it has taken in diseased blood, it becomes infectious in about a week. This is cyclical infection. It is found that in the interior of the flea, the trypanosomes are found not only in the cavity of the intestine, but they bore into its walls and are for a long time intracellular in their habits. They multiply in these cells and then make their way back into the cavity of the intestine.

Trypanosomes which affect man

1. T. gambiense: We have already discussed this type which was discovered by Ford in 1901 on the banks of the Gambesi in West Africa. He was examining the blood of a patient supposed to have malaria and instead of malaria germs he found this trypanosome. Various other cases were found in West Africa in people supposed to be suffering from malarial fever. The fever was then distinguished as trypanosomic fever, which is very like malaria and often mistaken for it.

About the beginning of this century, sleeping sickness, a disease long known in West Tropical Africa and described in chronicles of early explorers of that region, made its appearance as far north as the head-waters of the Congo. Stanley's exploring expedition is supposed to have had something to do with it, his native porters probably carried the germs. It spread in Uganda and all the districts near Lake Victoria Nyansa. It was a tremendous epidemic and carried off hundreds of thousands. The Royal Society sent a mission to investigate but for a long time they were baffled. In April 1903, Dr. Castellani an Italian, while examining the cerebro-spinal fluid of a typical case of sleeping sickness – i.e. fluid in the cavities of the brain – saw to his astonishment a trypanosome wriggling through it. He naturally suspected trypanosomes to have something to do with the disease. Later in the same year, David Bruce took up the question, he who had worked out the causation of Nagana. As soon as he learned of the discovery, his interest was aroused and he wondered if it was not a human tsetse fly disease. He and his colleagues set to work to test this idea. They examined the cerebro-spinal fluid and blood of a large number of persons and in every case this trypanosome was present in each. It became apparent that this was really the cause of the disease and that trypanosome fever was only the early stage of sleeping sickness.

They next tested question of transmission. The probability was a blood sucking fly. They caused extensive collections to be made of all the blood sucking flies of the regions. These were identified and maps were formed showing localities in which each fly was found. On another map was planned out the districts where sleeping sickness was prevalent. When they came to compare the maps, one fly map agreed exactly with the sleeping sickness map. The fly was *Glossina palpalis*. Wherever sleeping sickness was found, these flies abounded. This was nearly a proof that the creature was concerned with the inoculation of the germs. They set to work to prove this. They took a number of flies, allowed them to become infected and then let the flies bite monkeys. It was found that in a certain proportion of cases, the bite caused typical sleeping sickness. This was a complete demonstration.

At first it was thought transmission was direct, some took place in 2 or 3 days time, but they found there were two types of infection. One in 2-3 days and one 20-30 days later. After the second phase the fly remained infectious for months and probably to the end of its life. If we feed a number of flies on infected blood, not all develop infection. Only a few do, the others seem to be immune and the germ is killed. It is worth noting that there is some reason to suspect that occasionally, sleeping sickness is contagious. By various experiments it is seen that the creature can burrow through thin parts of the skin on the body without being actually injected. This however is not of any real practical importance. The *Glossina* is the main point. Practical importance is how to combat these epidemics of at least limit their ravages. In some parasitic diseases a number of things have been done, especially in the case of malaria. It is hoped to be able to do the same with this type. Unfortunately the problem is more difficult. In malaria, the insect carrier has a young stage spent in pools of water and it can be exterminated by treating the pools with oil. The *Glossina* however passes a long stage of its life inside the body of a parent. Instead of laying eggs it produces young at a late stage of development. This is a sort of grub which the parent deposits in the earth and as these are scattered about over regions, they cannot be destroyed. It was found however that there are two factors essential to life of *Glossina*, viz damp and shade. They live near water and deposit young within 30 yards of the banks of a stream or lake; further, they always place them in the shade of bushes or trees. We can do something therefore in a particular neighbourhood by cutting down the brush within 30 yards of water, and this greatly diminishes *Glossina* and thus copes with an epidemic.

Another difficulty is that *T. gambiense* is not naturally a parasite of human beings, but of wild animals. These animals are immune to the disease but the germ lives in their bodies and all these wild creatures which harbour it act as a kind of reservoir in which a supply is always available to infect the *Glossina*. We could kill off the wild game, but the trouble is there is a very great variety of wild animals, not only antelopes but many others such as wild rats and mice and it would be quite impossible to exterminate all those. Within very recent years, a new sleeping sickness appeared in Nyasaland and Northern Rhodesia but it is gradually spreading to Portuguese East Africa (once German East Africa). It is spreading and is extraordinarily virile, just as deadly as the old one and more rapid. It is a great danger of the future for it will spread over the whole continent of Africa. This is caused by the *T. rhodesiense* and is found to be carried by *Glossina morsitans*, the ordinary tsetse fly, which is found over all Africa, except the extreme north and south. Hence the great danger.

Lecture 9 *Trypanosoma cruzi* 25th Oct 1917

In 1909, *T. cruzi* was discovered in Brazil, not as a human parasite but as an insect parasite in a large bug called *Conorhinus*, called Benchuca in Argentinian. Dr. Chagas was examining the alimentary canal of Benchuca and he found a trypanosome like a common parasite. He thought it was not a parasite of a bug and so he took some infected bugs and allowed them to bite animals which then became infected. He wondered if they bit human beings. In the regions of Brazil where they came from, there were very common cases of a malarial disease, especially in young children. These were found to be the cause. The infection is cyclical. Chagas found that when a *Conorhinus* was fed infected blood, it took 7-8 days to become infected.

Set of important diseases produced by parasites

Leishmania, after Leishmann (a graduate of Glasgow) is a disease common in various parts of India, in Siam and Lower Bengal. It is a severe and malarial-like disease called Kala-azar. It is found also in the west of Asia. The cause was found to be in the presence of a curious parasite called *Leishmania*. It was found in 1900. Leishmann was examining cells from the spleen of patients suffering from the disease. He found imbedded in the cells little rounded oval bodies which were scattered about in the cytoplasm. On staining the cells, he found these bodies had two deeply staining parts. One round and the other rod shaped. They were found always in the patients and were considered parasites.

A little consideration suggests what parasites. They are arranged in the same way as the tropho and kineto nuclei of *Trypanosoma*. This was one which had gone through a peculiar metamorphosis. Rogers found these were the rounded off stage of trypanosomes. He could cultivate them in nuclear fluid, particularly if acid and in a warm temperature. They changed and lost rounded form and became elongated in shape with a yellow flagellum at blunt end. The two nuclei were still present. They were like trypanosomes of a genus called *Leptomonas.*

This parasite is often found in the body of insects but changed in the body of a human being. It is probably conveyed by bite of insects. It has been found in bugs and in the alimentary canal. They assume the *Leptomonas* form. This points to the bug as carrier. It is also common in dogs, therefore it may be a parasite of dogs and foxes etc. naturally. From this natural host, it may have passed secondarily to man. The order is *Leishmania donovani*.

There are two more species known. *L. tropica* and *L. infantum*. The latter causes disease like Kala-azar, especially in children of Algiers and Tunis. It is also found recently in Italy. *L. tropica* is found in the tropical ulcers of skin and is common in the East. It only causes a local sore, not a general disease. These ulcers occur on exposed parts of the body and suggest an insect is responsible, which is not a creeping but a flying creature. A fourth species not yet named is found in Brazil and Paraguay, it causes sores on the surface of the body, bad ulcers supposed to be syphilitic in nature, but which we now known to be caused by a species of *Leishmania*. The great characteristic of Flagellata is that they swim by means of flagella for the main part of their life.

Sporozoa

This is a group of great practical importance. It has important types of parasites and it is a characteristic of the whole group that they all live as parasites in the bodies of other animals. It is easy to obtain suitable material in which to trace out without difficulty the life history of one genus. This is *Monocystis*. It is found as a parasite in the ordinary earthworm. When we dissect an earthworm, towards the front end there are conspicuous organs, whitish or pale yellow in colour called Seminal Vesicles. These are little hollow organs in which the microgametes of the worm develop. They are filled with a whitish material which under the microscope consists of microgametes in various stages of development. The most conspicuous stage has the form of a spherical mass of protoplasm, the surface of which grows out into numerous rounded projections like a raspberry. This is the Sperm Morula, a stage in the development of microgametes.

Each rounded projection will gradually take on a pear shape and later it would become drawn out into a long thread like structure or microgamete. These break off and mass disintegrates. With an infected worm, however, occasionally there is present inside protoplasm of sperm morula a little elliptic shaped body with a nucleus. This is the young stage of parasite.

The monocystis goes on living and absorbing nourishment from the sperm morula. It increases in size, becomes more elongated in shape and as it does so the sperm morula becomes distorted and loses spherical shape although the microgametes go on developing. The monocystis increases in size and assumes pear shaped form. The sperm morula is stretched out all over its surface until it is only a thin film around parasite. The microgametes have still gone on developing and have reached hair-like forms. The monocystis seems to be ensheathed in a furry coat, but each hair is a microgamete. All this part of the life history is known. It is the trophozoite stage. If asked to define meaning, it is the stage of life history of Protozoa during which it is absorbing nourishment and increasing in size. When it reaches full size it bursts its way out of the remainder of the sperm morula, loses its furry covering and lies free in the cavity of the seminal vesicle. It is a single cell composed of nucleus and cytoplasm. It has a definite cuticle. The main part of cytoplasm is crammed with shining granules. These granules are reserve food material which the monocystis has been storing up.

During the trophozoite stage there is no reproductive process but now there comes about a new part of life history called Sporogony, which proceeds as follows: two of these completely formed trophozoites take on a rounded form and surround themselves with a spherical cell or cyst. These two individuals which are associated together in cyst are gametocytes. If we watch them, we find nucleus of each divides over and over again and the small nuclei pass out to the surface of cytoplasm and each becomes contained in a little projecting part of the cytoplasm. Then projecting pieces become ripped off from the rest and these pieces are the gametes of *Monocystis*. The rest of the cytoplasm simply disintegrates and disappears. It is known as residual protoplasm.

Interesting point in form: the two lots of gametes are different in size. Gametes from one gametocyte are smaller than the others. These gametes begin to move about in the cyst, become mixed up and a process of syngamy takes place. Then they become completely fused. The nuclei fuse and now we have a zygote formed by the union. The interesting point is that in the cyst a large and small gamete fuse together. Thus the zygotes formed are produced by a gamete from each original gametocyte. The zygote when formed, proceeds to surround itself with a shell as is usual with zygotes. It is canoe-shaped and called Pseudonavicella. This name comes from a plant diatom which was boat shaped and called navicella. This being of a similar shape, it got its name.

In this shell of cyst the zygote undergoes a characteristic change. The nucleus divides up three times in succession. We have now 8 nuclei and the protoplasm divides up also into eight sausage-shaped pieces called sporozoites. If a bird eats the worm or it dies, the cysts break up and the Pseudonavicella get scattered through the earth. Garden soil is often full of them. These serve as infection for other worms. When worm swallows infected earth, the wall of the Pseudonavicella is digested and the sporozoites are set free in the alimentary canal. They burrow this way into its walls and begin life history afresh.

Another sporozoite which causes malarial fever, the most deadly of all diseases and marked by more suffering and higher death rate than any other, is called *Plasmodium*. As we all know, malarial fever is characterised by high temperature which is not continuous but comes in successive attacks. These come at fixed intervals. There are three types (Table 3).

If we examine the blood of a malaria patient just after a fever attack, the blood gets its red colour from the red blood corpuscles, circular discs containing red colouring matter or haemoglobin. This important substance in the body has the power of uniting readily with oxygen. It forms a compound which however is easily split up. This fact is made use of it serves as vehicle which carries oxygen through the body and hands it over to various parts where it is required. We will find some of the red corpuscles have got within them a little amoeba-like parasite called an amoebula. This is the very young trophozoite of *Plasmodium*. It lives at the expense of

Tertian malaria	Period 48 hours	Two attacks in 4 days
Quartan fever	Period 42 hours	Two attacks in 6 days

Table 3. Types of malarial fever in humans.

the blood corpuscle, increases in size and develops a large vacuole. This gives it the appearance of a signet ring. It is called the ring stage.

Not only does amoebula increase in size, but the cytoplasm deposits little granules of dark brown, nearly black pigment, called melanin. It is really the product of digestion of haemoglobin. This is characteristic of malaria, the formation of dark brown pigment all through the tissues of the body.

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The trophozoite of *Plasmodium* goes on growing in the corpuscle until the parasite comes to occupy the whole interior. This full grown creature becomes what is called a Schizont i.e. it produces by Schizogony. The nucleus divides several times over and we have a number of nuclei scattered about the protoplasm. This divides into as many pieces as there are nuclei. Each piece has a small nucleus. During this process the dark brown pigment is not divided up but is left out and ties between them.

Soon the blood corpuscle bursts and in its place is a group of more or less amoeboid looking creatures with a heap of melanin pigment amongst them. These are called Merozoites. The group becomes scattered and individuals creep away into the blood. Their fate is to bore into blood corpuscles and become a young amoebula and thus begin cycle afresh. This is a Schizogony cycle.

At the moment when the blood corpuscle bursts, the merozoites are set free in the blood and there goes with them a virulent poison. It may be the melanin itself or some invisible companion. This is important for all the parasites keep time in this process and the whole cycle occupies a definite number of hours: 48 hours in one type, 42 hours in other. At the end of every period, hours as case may be, the considerable quantities of the virulent poison send up temperature and give rise to fever attack. This process goes on over and over again. Effect is that a greater and greater proportion of the blood corpuscles become affected. Thus spreads infection in the body. After a time there commences a new part of the cycle. The Sporogony part begins like Schizogony. Merozoites bore into corpuscles and become amoebulas. These grow inside until they occupy the whole cavity. They don't become Schizonts or break into merozoites. There are two different kinds and as they increase in size, differ slightly when free from corpuscle. One type is larger.

These have a large nucleus rather towards surface of parasite and the cytoplasm takes on certain stains. A very deep colour for its cytoplasm is crowded with granules of reserve food material or a kind of yolk.

The other type are much smaller, the protoplasm has no deeply staining granules. The nucleus is not at one side but in the centre. One rich in chromatin and thus staining deeply.

A patient with this stage of parasite has blood, which if examined under microscope while alive in about half an hour, will show an extraordinary change coming over parasite. The larger type, its nucleus divides and one half is passed out to the exterior. That nucleus is now a polar body.

In the other type it is different. The nucleus divides up to 2 or 3 times, at least twice. Small nuclei are produced which rise towards the surface of the parasite. Suddenly its cytoplasm shoots out into 6 long slender filaments. Each has a small nucleus drawn out into a thread-like shape.

These filaments lash violently about from which fact this is called the flagellated stage. These are not flagella they are microgametes. After end of half an hour, these wave so violently they break off from centre piece and if another type is about the filament swims towards it, comes in contact and is drawn into interior.

Now we have a spherical cell with a single nucleus formed by fusion of its own and the thread one. Thus, thread is a microgamete, other is a macrogamete and the product is a zygote. These previous stages after bursting are either macrogametocytes or microgametocytes. This is the meaning. When the blood cooled, the cooling made this process of syngamy take place. The next phase in life history is passed in a cold-blooded creature, i.e. a mosquito in which the above process takes place. Mosquito means little fly but used in England we mean a particular kind – a gnat – common British gnat, Genus *Culex*. It is also common in tropics where it is known as a mosquito. If we watch how they bite:

SPOROZOA	HOST
Telosporidia	
Gregarinida *Monocystis*	*Lumbricus*
Coccidia	Arthropoda
Haemosphoridia, *Plasmodium, Babesia*	1. Man 2. Cattle
Neosporidia	
Cnidosporidia	
Myxosporidia	Fishes
Microsporidia, *Nosema*	Bees, Silkworms
Sarcosporidia	Sheep and mice
Haplosporidia - *Rhinosporidium*	Nose of man

Table 4. Types of Sporozoa and their Hosts.

Culex: It is hunch backed, its proboscis is bent downwards. There is another kind *Anopheles*, when it bites it is in line of proboscis and appears to be standing on its head.

Anopheles: This is the malaria carrier. *Culex* is not. If a culex ate gametocytes they are killed and digested but in *Anopheles* this process would begin in the alimentary canal and zygotes would be present. All the other stages, schizonts or amoebulas, are killed and digested, only the gametocytes live. The zygotes alter in shape, from spherical to worm shaped. This creature creeps actively about, an unusual feature as zygotes are nearly always motionless. This is an ookinete. It creeps about and comes to wall of alimentary canal, it proceeds to burrow through it and finally arrives on the outer side where it assumes its spherical shape.

It absorbs nourishment from the blood and grows in size, its nucleus divides several times over and then protoplasm divides into pieces each with its own nucleus. Each is a sporoblast. The spherical zygote has increased in size and divided into these. It goes on increasing and we find each sporoblast undergoes characteristic change. Nucleus divides over and over again into thread-like nuclei and these pass out into thread-like pieces of protoplasm which develop on the surface of sporoblast. These thread-like things are sporozoites. Residual protoplasm, the centre part is left, only the surface part is used.

A sphere may contain many thousands and this mass bursts and myriads are set free in the mosquito's blood. These make their way forward and eventually penetrate into salivary glands.

Hollow-shaped radiating cells surround tubular cavity or duct of a gland, tube by which saliva passes out. They bore in, crowds of them. Some don't stop there, a number get into the cavity of duct. This completes cycle. From gametocytes to sporozoites takes 10-12 days. When the cycle is completed the mosquito has these in the duct and when it bites, saliva is injected into the wound, slushes gland and sweeps parasites into the bitten person. If they succeed in reaching a blood corpuscle, they burrow in and become amoebula, starting history all over again.

A curious fact about malaria is that if you have it and recover, you are liable to attacks after intervals even as long as five years. Somehow or other the parasite remains in the system although there is no disease. It is an interesting problem how the parasite remains there. We have two distinct views. The general one is that as you recover and kill off parasites, one particular phase is resistant and not killed, the macrogametocytes. These have great powers of resistance for long periods. If you get below "par" and system is run down, these parasites are stored up and behave like Schizonts, produce merozoites and the whole concern starts again.

Another view is that not only macrogametes, but practically any stage survives. The idea is that parasite goes on living in small numbers, reproduces but never sufficiently to cause fever. With system below par, they start again. We must notice three distinct types of parasite which differ in small details and are therefore distinct species.

Plasmodium vivax	Tertian Fever
P. falciparum	Malignant tertian or tropical fever
P. malariae	Quartan fever

Table 5. Species of *Plasmodium* and fevers in humans.

How to identify: All agree with general life history, but important difference is that *P. falciparum* has got a very characteristic feature, the shape of the gametocyte is crescent-shaped. It is called the crescent stage. In other cases it is round.

Thus these crescents in malarial blood point to malignant tertian. The other is the number and arrangement of merozoites. *P. malariae* has this characteristic in it, there are 6-12 merozoites in each group and these are regularly placed in a little rosette. In *P. vivax* the merozoites are more numerous, 15-20 in a group. In *P. falciparum*, 8-32 and in this case, merozoites have no regular arrangement. The clinical difference is the time between successive attacks, 48 hours in tertian, 72 hours in quartan and in malignant tertian, 48 hours or less. It is not so regular.

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We have this knowledge: it begins with Sir Ray Lankester in 1871, in the blood of the frog he found a parasite *Drepanidium* (*Lankesterella*). It is the first example of this group of parasites to which *Plasmodium* belongs. Next advance, Laveran, a medical officer in the French army in 1880, described various parasitic creatures found in malarial blood, no one believed then but now we recognise that he discovered the parasite of malaria as well as the various stages: amoebula, merozoites, gametocytes, the male producing projections round the body, flagellated stage of parasite, but Laveran made tremendous advances in our knowledge.

Next McCallum, a Canadian working at Baltimore in 1898 found malarial parasite in birds, the male gametocyte, he saw flagella break off, swim and undergo syngamy with another parasite. He at once saw the meaning, the flagella were microgametes and the spherical ones macrogametes. Ronald Ross in India also in 1898 found connection of malaria with mosquitoes (known before but not investigated): he tested this parasite in birds and he was able to show how the gametocytes were taken in with the blood of the bird by *Culex*. This gave rise to zygotes which again gave rise to sporozoites. He was able to demonstrate that *Culex* infected a new bird.

Shortly after, the Italians, 1901. Grassi found bird malaria and history of parasite was same as human. In case of birds the carrier was the *Culex* but in humans

Anopheles. Although the Italians get the credit, Ross was really the discoverer: it was a dappled winged mosquito which carried human parasite. This was really the *Anopheles*. The final touch was Schaudinn who completed the business by observing the penetration of sporozoites into the blood corpuscles.

In Telosporidia, the reproductive processes are concentrated together and occur after the period of growth of trophozoite (after process of feeding and growing).

First subdivision: Gregarinida which includes *Monocystis*. The characteristic of trophozoite is that it is intracellular. It is in substance of single cell but this cell is never a blood corpuscle. Later on it becomes free from the cell and is found living in some cavity of the host's body. In Gregarinida there is no schizogony process but only sporogony. This results in formation of sporozoites usually many in number, enclosed in a special little cyst. The trophozoite has a characteristic movement, neither by cilia or flagella but by euglenoid movement. It also shows a curious gliding movement which is produced in a remarkable way. The creature secretes a jelly like material at one end. This pushes it forward. They are common parasites in the lower forms of animals.

The second group: is Coccidia which are again parasites in a great variety of the lower animals. We get them partly in the class of animals known as Arthropoda (insects, shrimps, centipedes), partly in rabbits in which it often causes destructive epidemics. The parasite is again intracellular but in this case it stays in the cell, it is not free like Gregarinida. It increases in size, spherical shaped and it destroys and kills the host's cell.

The danger in this process of schizogony is that the crowds of merozoites are set free to penetrate new cells. Thus enormous numbers of cells are completely destroyed finally causing death of host. It is succeeded by sporogony, zygotes are produced and these are surrounded by a cyst. These parasites are spread by sporogony in the cyst which is swallowed like *Monocystis* by a new individual. The cyst is dissolved and the parasites take back their abode again.

The third group: Haemosporidia, to which malarial parasite *Plasmodium* belongs, has the following special characteristics. The trophozoite as a rule is intracellular, in this case amoeboid in form. The host cell is typically a blood corpuscle. The process of schizogony and sporogony culminates in the formation of sporozoites but these move about freely instead of being confined in a cyst or shell. In this case also sporozoite phase is spent in a different animal to schizogony which is in vertebrates but the former is usually in a blood-sucking insect.

Besides *Plasmodium*, there is *Babesia* or *Piroplasma*. This genus has for an example the best known *B. bigeminium* causes Texas Fever, a destructive disease of cattle in the southern states of North and South America where it is called Tristeza. In South Africa and Australia it is called Red Water Fever. Sporozoite stage is in blood corpuscle as a small oval-shaped parasite. This trophozoite undergoes schizogony in corpuscles and we often find two parasites produced by schizogony or fission. This suggested the name bi-geminium. There are sometimes four or even eight. Whether there is sporogony has not yet been discovered. *Babesia* is transmitted by ticks belonging to genus *Boophilus*. They attach themselves to the body and hang on for about 3 weeks, sucking in blood and eventually they drop off. The parasite is transmitted only by adult female ticks. If a fully developed female takes in infected blood, parasites are set free in the alimentary canal. They undergo change in shape, develop rod-like pseudopodia and creep away into various organs until the whole body is infested. Among other parts, the ovaries in which they burrow into substance of eggs. When the tick drops off the animal, it deposits its eggs and after a time (20-45 days) these hatch out and young tick is infected and can convey infection. This is a type of cyclical infection not met before, the descendants spread the infection. This explains a curious point about Texas Fever – When herds of cattle were driven north from the southern states where the parasite was common, they infected pasture lands through which they passed. These epidemics did not appear at once, only about a month after infected herd had passed through. This gap was very puzzling but now we know the reason.

Similar species of *Babesia* occur in Europe and Northern Africa. *Ixodes* or common European tick is the carrier. This causes another destructive disease of stock. East Coast Fever in South and East Africa and Asia. The parasite is a little smaller, Genus *Theileria.* The great characteristic of all diseases caused by *Babesia* and its allies is that the animals infected show tremendous destruction of red corpuscles. The result is that the haemoglobin is discharged into blood, passes to kidneys and thence to urine hence the name and destructive nature.

The second subdivision: Neosporidia differs in the fact that the reproductive processes instead of being concentrated are scattered all through life history. When the creature is a trophozoite it goes on with reproduction. These are carried on by reproductive cells called spores.

i) Cnidosporidia: these above all are characterised by spores, each is a rounded or oval body but special feature is near one side it has two little bodies, Polar Capsules. Examined under high power these show curious spinal markings. These are very interesting for if we put a spore where it is subject to digestive ferment, an explosion takes place and these shoot out from the end of a thin tube. This was originally coiled up, outside in, within the capsule causing spiral marking. When the spore is subject to digestive ferment, the capsule explodes and shoots out this tube to anchor spore in position in the alimentary canal of the animal that swallowed it. It shoots into substance of wall and anchors spore securely. There are a number of parasites characterised by spores and polar capsules.

1st Myxosporidia: common in fishes, it causes destructive epidemics. In this case parasite is amoeba-like with distinct ectoplasm and endoplasm. The ectoplasm shoots out into pseudopodia in front. These are only used for creeping and holding on. It absorbs its nourishment all over the surface of the body. Within protoplasm are numbers of nuclei. It is common, especially in winter for spores to be produced in endoplasm while the creature is still growing.

2nd Microsporidia: These are found sometimes in fishes but more commonly in insects and at least two are of great practical importance. Two species of the Genus *Nosema*: one causes a destructive epidemic in silk worms- Pebrine disease, the cause of which was among the great works of the Frenchman Pasteur who prepared the way for Lister in antiseptic surgery. The other causes a disease of bees, Isle of Wight disease, this is not quite certain however for a diseased bee has *Nosema* and also bacteria in the weakened body. Which is which?

3rd Sarcosporidia: is a parasite of vertebrates such as sheep, as far as is known they do no harm. But in the mouse it is a destructive disease. These have the characteristic appearance being of enormous size compared with most Sporozoa. We find them in the muscles of a mouse, heavily infected, running through the muscles is a long whitish thread which is a single parasite.

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The muscle fibre of vertebrates is elongated in shape and the parasite burrows into it as a small amoebula. It penetrates muscle fibre and increases in size, eventually increases in length to form a thread visible to the naked eye. It is granular in appearance and has a number of nuclei. The whole protoplasm of parasite divides into little crescentic shaped spores.

The Sarcosporidia are not as a rule dangerous only occasionally the parasite becomes ruptured and the broken up contents are set free and with them a virulent poison. This does no harm when shut up in living parasite. This causes a pathological disease.

The life history is not known or the means of infection or spreading from host to host. If a mouse eats an infected mouse it in turn becomes infected but sheep do not eat each other so there must be some other means.

Haplosporidia are fairly common parasites in fish such as plaice. One has been discovered in the human body causing a curious tumour formation but these cases are extremely rare such as *Rhinosporidium* in the nose. All these creatures go into group Sporozoa which is characteristically parasitic. Again, they are characterised by the fact they never have cilia or flagella when fully developed. They are covered with continuous cuticle without an opening and feed by absorbing nourishment through whole of general surface.

4th Subdivision: Ciliata – *Paramecium*

These ciliata have a definite shape owing to fairly stiff cuticle. Although shape is definite in one type, there are a great variety of forms in the various groups. These ciliata show the greatest complexity in structure found in any creature. The most complicated individual cells in animal or vegetable kingdom belong to ciliata. An individual of one cell with different parts showing in a wonderful way organs in miniature. The body is bounded by distinct outer layers which may be very complicated in parasite. There is the cuticle, a thin bounding membrane. Then layer of trichocysts, then deepest layer of ectoplasm characterised by the fact that protoplasm differentiates (under high power) into little bands, myonema. The interesting point is myoneme is the beginning of muscle. It is a strand of protoplasm which has derived the property of contracting in length owing to their presence. The ciliata can distort their form from time to time. Sometimes these are very well developed. There is Ciliata *Vorticella*, a bell-shaped creature on end of long stalk. It can contract into a spherical shape and shoot down to plant to which it adheres. Inside the stalk we can see under high power a well-developed myoneme running in a spiral strand round stalk. This pulls it down. The endoplasm is very ordinary. The ciliata has usually a distinct mouth opening. The cuticle is continued through mouth opening into a tube or oesophagus. The nuclear appearance is very striking characteristic. In all typical examples it is in two portions, macro- and micro- nuclei. The macro-nucleus looks after the metabolism while the micro-nucleus is purely reproductive in function. We find these vary in shape in different members of the group. In *Paramecium* the macro-nucleus is of a large kidney shape and micro-nucleus is small and lies near the former. In *Stentor* the macro-nucleus is like a string of beads and micro-nucleus is a small sphere close by.

Stylonychie has a dumbbell-shaped macro-nucleus with a small pair of micro-nuclei. In *Vorticella* former is horseshoe-shaped while latter is small and spherical.

These get the name ciliata because they possess cilia by which they move. In *Paramecium* in sub-division (a) Holotricha the cilia are scattered about body in a uniform coating-the simplest condition. If we look at *Stylonychie* in sub-division (b) Hypotricha the cilia have disappeared while on other parts they are fused together into bunches or clumps, solid leg-like structures and it can creep about on these on smooth places. In *Stentor* the cilia are all over the body. They differ in characteristic coating of small cilia, but round the peristome they are clumped together: instead of legs, they form flat plates. The object is to make a whirlpool and bring down the food.

Peritricha cilia: *Vorticella* has none save round mouth. Closely allied to ciliata is the group Suctoria, commonest genus *Acineta*. This specimen has a triangular shaped body borne on a kind of stalk. The lower part is sheathed in clear stiff material which is prolonged into stalk. It fastens on water plants. On the upper end are minute things like little pins, slender structures with heads on end. Under high power each pin-like structure is a long slender tube with trumpet-

shaped mouth. Its function is that if small cilia are touched by a particle of food, movement stops and the protoplasm is drawn inward through the tube by which it feeds. It has a nuclear apparatus like ciliata with macronucleus and micronucleus and contractile vacuole.

It swam in early stages before the tubes had grown and it had adhered to anything. It swam like a small ciliate. They are really ciliates which have diverged.

There is another interesting parasite of the genus *Spirochaeta*. It is an organism of extremely minute size and details are difficult to make out. It is a puzzle which of the other protozoa they come nearest to and whether it is more correct to look on them as small animals or as plants. It is thus a doubtful creature and can be properly regarded as a rather intermediate stage than as belonging to either class. They have a very definite characteristic shape. They are in the form of spiral coil or corkscrew coil. Their cytoplasm is full of granules and it has recently been discovered the spiral is prolonged into flagella. By means of these the creature swims. It has a characteristic movement, shoots in one direction then movement is reversed and it goes in the other direction. Straight lines first one way and then the other. These spirochaetae are common in various animals such as fresh-water mussel in its alimentary canal.

Diseases such as relapsing fever are caused by spirochaetae. The relapsing fever of tropical Africa is caused by a spirochaeta called *S. duttoni*. It measures 16-24μ in length. The particular feature of these fevers is that fever comes in successive attacks. The spirochaeatae show a periodic increase in numbers for they reproduce by fission at certain times with tremendous activity until the whole body is swarming. The numbers gradually die away and fever disappears then shortly they start again.

These parasites are conveyed by individual to individual by the bite of ticks. In Tropical African fever the tick is *Ornithodorus*. It takes in infected blood, then spirochaetae reproduce with great activity and the whole body is infected. The tick is now capable of conveying infection. It inoculated germs and infects the new individual. It resembles the *Babesia* parasite in the fact that the ovaries and hence the next generation are infected. In *Babesia* only the progeny are capable of conveying infection but in this type not only the progeny but also original adult can do so.

Besides this fever there is also a type once common in this country but which has now disappeared, still found however in eastern parts of Europe. This is European Relapsing Fever, *S. recurrentis*. It differs in size, being 4-10μ in length. In determining the type of fever we can easily tell by size of spirochaetae. In European type, infection is conveyed by lice but not by the bite however. It takes in infected blood and its own body gets swarming – By the way, for a little while afterwards it is impossible to find any spirochaetae, they cannot be traced. In one examined after 24 hours from time of infection, not a single parasite was to be seen, but in a week they made their appearance and from 8th-19th day the insect was swarming. This is the period of ability to transfer infection. After 19th day parasites diminish in number and disappear apparently finally – It is not conveyed by bite but if an infected insect is crushed on the body of a new individual and the contents get on to the skin, or places like the eyeball, where skin is thin or where there are cuts or scratches, the parasites find their way into the blood and cause infection.

Parasite of Syphilis is also of this species, *S. pallida*. Yaws, a tropical disease, too has the parasite *S. pertenus*. Infectious jaundice has parasite *Icterohaemorrhagiae*. Relapsing fever, *S. dulloni*. European R.F., *S. recurrentis*.

Rat-bite fever: in Japan supposed to be conveyed by the bite of rats is also caused by a parasite which is minute in size and multiplies by fission. In some spirochaetae, especially in mosquitoes, under certain circumstances division by fission is so rapid that as they divide in halves they get smaller and smaller until they get so small they pass beyond the limit of our highest powers on the microscope. Thus we get a case of invisible germs. A microbe too small to be seen. There are a number of diseases due to germs but in which there has been complete failure to see a germ. Such an example is Yellow Fever: we know there is such a germ or microbe and that it is carried by a mosquito called *Stegomyia*. We also know the size although it has never been seen. Filters are used to filter bacteria and are made in different degrees of fineness. The infected fluid is filtered through finer and finer pores. They start with coarse filter and germs come through, for fluid is still infectious. Take it on the to the next filter until finally in some one of the series the germ is stopped, thus we have a rough measurement. Apparently the germ is present in the blood of a yellow fever patient during first three days. During that period if a mosquito bites the patient, it becomes infected and after 12 days it can infect a new individual. Thus it has cyclical infection so there must be a life history going on. *Spirochaeta* has given us a definite known example of invisible germ and yellow fever suggests that germ may be simply a very minute spirochaeta.

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There are one or two other diseases caused by invisible germs.

Dengue fever: Common in warm countries: has never revealed its germ to us, but these epidemics of fever occur only where a certain species of mosquito is found. *Culex fatigans*. Places where it has been exterminated are free from fever.

Sand Fly Fever: Conveyed by *Phlebotomus,* a small midge, is common in Mediterranean countries and eastwards to India. It is clearly due to the bite of the sand fly which can convey infection only about 7 days after taking in infected blood. Thus the infection is cyclical.

A third disease, although evidence is not so clear, is Infantile Paralysis which often occurs as an epidemic. Again a fly, *Stomoxys* is blamed. In recent years it has turned out that a kind of Protozoa is responsible for various diseases grouped under the name of Chlamydozoa. Among these are smallpox, scarlet fever, hydrophobia, trachoma and also a disease of sheep called foot and mouth disease. In the cells of an infected body were seen curious little rounded bodies which when first discovered were supposed to be parasites. However these are not in themselves parasites, they are a kind of reaction on the part of the cell to the presence of the real parasite. If these little bodies are examined under the highest power, in the centre will be seen an extremely minute, deeply stained dot. These have a dumbbell shape as if divided into two or undergoing fission. These chlamydozoa are the parasites and protoplasm surrounds them with a cyst.

Points about protozoan parasites: Large numbers have taken a parasitic existence, some cause diseases of a severe kind but the production of disease is not a normal characteristic of a protozoan parasite. In any one particular locality in the world there is a definite set of animals and these have a definite set of protozoan parasites. Normally these two sets are associated for long periods of time and they get accustomed to each other, so no disease is produced. A great struggle for existence goes on in nature and not only is a handicapped individual apt to be exterminated but also all the strain which it represents. Thus strains with a particular weakness tend to be eliminated, so with parasites, where a particular type of parasite is in a particular type of animal. Animals liable to disease are handicapped in struggle and so are weeded out. Species as a whole is not liable to disease. Look at the relation of parasite and host. If host animal is inoculated it may behave towards parasite in three different ways.

1. Repellent: If introduced into blood of host it is at once killed off.
2. Tolerant: In this case parasite goes on living and multiplying but never sufficiently to cause disease. Living activities of host keep it under control
3. Susceptible: In this case, parasite not only goes on living but it multiplies so greatly that it overruns the body of the host, interferes with activities and produces symptoms of disease.

Evolution: Susceptible individuals in any neighbourhood are cleared out. When we do get disease produced is when a particular kind of host and parasite are brought together which have not had time to get accustomed to each other, that is before susceptibility has been eliminated. Thus when brought together for the first time, disease is generally produced through the actions of human beings, hosts are introduced to some part of the world where they meet local parasites to which they are not accustomed. Take the case of Malaria: the white man goes to the tropics where the natives are tolerant while he is still susceptible, not having had time to get weeded out, he meets the parasite, falls a victim and develops disease.

Nagana is another example. Cattle in fly belt regions meet with the trypanosomes and instantly disease is produced. Disease is also caused by migration of hosts.

In other cases, epidemics are caused by movements of parasites and not hosts. The yellow fever parasite is carried to some place strange to it and then violent disease results. Sleeping sickness is the same. *T. gambiense* was transported up to Congo probably by Stanley's men. Thus there is always the dangerous possibilities of disease being carried into unknown regions with fatal results. Yellow fever is a disease found particularly on east coasts of tropical America and west coasts of tropical Africa. Its prevalence and conveyance depend on presence of the mosquito *Stegomyia*, one which is widely distributed throughout the tropics of the world: East Africa, India, Malay Peninsula, Islands of Malay Peninsula, Queensland etc. Thus if this germ is carried east, for *Stegomyia* is transferred in ships, all these districts may be infected. Malaria called by us 'ague' was once quite common in this country; it has practically disappeared because English mosquitoes were no longer infected. But, at present, numbers of men in the war are coming home with malaria; there is the possibility of our mosquitoes again being infected and it is perfectly possible malaria will become prevalent again.

Phylum Protozoa: This group is one of the main groups of the animal kingdom, its special features are: first, most usually it is composed of unicellular individuals. That cell may undergo fission and divide up but in such a case these separate and lead their own lives independently. These protozoa probably represent the most ancient type of animal life. In the earliest days of evolution, first animal was probably protozoan. But although protozoa are extremely ancient and simple, we may find individuals showing very great complexity in structure such as Ciliata. In feeding, the protozoa digest food in the body of the cell, intracellular digestion. They reproduce by fission if an individual protozoan is kept under favourable conditions such as a *Paramecium*. In due course it undergoes fission and new individuals again divide up. As time goes on the activity of this process slackens off and takes place more rarely until it finally stops. *Paramecium* might divide 200-300 times. It doesn't begin again unless by some stimulus, which is normally afforded by process of syngamy. The zygote has powers of fission renewed and it starts again for 200-300 times, and so on. All remainder of animal kingdom we class together in the set Metazoa. When metazoa begins life history, like the protozoa it consists of a single cell, the difference comes out later. This zygote undergoes fission, 2-4-8 etc. It goes on dividing for a definite number of generations but here the produced cells instead of separating, remain united to form a single individual. Owing to this fact about the process of fission, normally the individuals of a particular kind are approximately all of the same size for the process goes on for some time. The first result is that in the point of size, metazoa are enormously larger than protozoa. Correlated with these cells we see a wonderful division of labour, different sets and different tissues. Each tissue

or set of cells having to perform some particular function.

1st Division: Gonad and Soma: The gonads are made of the cells which retain the power of undergoing syngamy. The soma or greater part are cells which have lost that power and so perish. It is the soma which forms the great bulk of the body, it is of enormous size, its cells undergo differentiation into different groups for different functions.

One other point: the protozoa are creatures which all live in watery fluid, if dried they at once die. Thus the general feature of living protoplasm is that it can only live if the surface is bathed in fluid. In metazoa therefore, the whole body is permeated with watery fluid lymph, the medium in which cells live. It is sometimes called the internal medium. The external medium is either air or water. This lymph is very important. It is not pure water but fluid of great complexity. Into it diffuses constantly the various products of the metabolism of the body. Each particular part gives off definite fluid which passes into the lymph.

The point is this – that every cell in the body does not give exactly the same substance. Every type of cell has its own peculiarities in the particular substance which it gives off and the result is that the internal medium is not only tremendously complex but the composition is definitely made up of contributions of a particular type from each particular organ. If the balance gets upset and one set of cells pay out too much or not enough, it means that the composition of the medium becomes abnormal and disease is produced.

Skeleton	As the body is composed of semi-fluid protoplasm, it would be unable to retain its shape without supporting tissue.
Muscles (Muscular system)	Cells which have especially developed the power of contraction. These are bands of cells attached to skeleton by their ends and so move parts of the skeleton and hence move the body.
Nerves (Nervous system)	These are for the purpose of receiving impulses and impressions from the outer world and for the purpose of transmitting impressions from one part of the body to another. Impulses to the muscles and finally keeping up general control over living activities. Besides these, those connections with metabolism.
Alimentary system	Function is the taking in of food, digestion, absorption of products.
Blood vessels (Transport system)	Consists of cells arranged in the form or tubes, i.e. blood vessels, containing other cells which float free in liquid, the blood. The tubes are muscular in character whose pieces can contract and pump blood through system of vessels.
Renal system (Renal organs)	The function of these is to extract the more or less poisonous waste material from the blood and pass it to exterior of the body.

Table 6. General types of tissue in Metazoa.

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ABSTRACT

The Editorial Introduction describes the origin of this set of short articles on the first 50 years of the Zoology Building. A celebration of the first five decades was held in 1973, and the Regius Professor, David Newth, facilitated the writing of a commemorative pamphlet including articles by departmental members, past and present. The articles, not published formally before, are reprinted here followed by an explanatory Appendix compiled by the editor. Following a short news item from *The Glasgow Herald* (1921) announcing the new building, there are four articles. The first, by Agnes "Nora" Miller, lecturer 1924-1963, gives her reminiscences over four decades. The second, by Sir Maurice Yonge, Regius Professor 1944-1964, focuses on the teaching, research and changes to the building during his time at Glasgow. The third, by David Newth, Regius Professor at the time of the 50 years celebration, covers the changes during his time of rapid development in the place of Zoology in higher education. The final article, by the editor, concentrates on student activities, such as the Zoological Society.

EDITORIAL INTRODUCTION

In 1973, Regius Professor David Newth realised that it would be opportune to celebrate the Zoology building's first 50 years. As a contribution to the celebratory events, he asked me, as a recently appointed lecturer (1970) and also a graduate of the Department's degree in zoology, to assemble a pamphlet recounting the Department's history, and he arranged for funding from the University Court to cover the printing costs. He also arranged for short memoirs to be written by past members of the Department: Agnes Miller (Lecturer 1924-1963; died 1994); and the previous Regius Professor, Sir Maurice Yonge (Professor 1944-1964; died 1986); he wrote his own account of recent developments (Newth was Regius Professor 1965-1981; died 1988). In addition, I contributed an account of student life in the department, incorporating some reminiscences from before World War 1, written by Sister Monica Taylor (1877-1968; D.Sc. 1917; Head of Biology at Notre Dame College, Bearsden, Glasgow until 1946).

The pamphlet included lists of staff and students over the period 1924-1973. We have not included these here. The data on student numbers, along with those from 1973-2023 have been used in the next section, *The Flourishing of Glasgow Zoology*, to demonstrate how the impact of zoology had grown. We reprint the 50th anniversary articles here, as they were written, with the addition of an Appendix of notes to amplify the information provided (referred to by superscripts in the text). We also include some of the photographs from the pamphlet plus a few other illustrations that seem appropriate. We have not given the contact details for the authors since all are deceased, except the editor whose details are on the first page of this section. The section on members of the Department, alluding to the possibility of mistakes in the lists, included the sentence: "the editors of the centenary edition will doubtless be happy if you let us know of our blunders now". I certainly did not expect, in 1973, that I would be the editor of the centenary edition, but repeat the invitation to inform us of errors you spot, or extra information we could add, in the event of a future edition!

I noted in 1973 that "the department appears to have been a happy, companionable, even romantic place" given the number of marriages that have occurred between fellow students and even between staff and students. The long hours spent in laboratories and on residential field courses, and the fairly equal numbers of male and female students probably contributed to this process. I think it is fair to say that the air of conviviality, allied to hard work, continues to the present day.

Authors' names at the start of the following articles are formatted as in the original publication.

GLASGOW UNIVERSITY: NEW NATURAL HISTORY BUILDINGS

From *The Glasgow Herald*, Saturday, 25th June, 1921

Glasgow University is soon to be provided with a building to "house" its Natural History department, particularly that branch of it dealing with zoology, worthy of the reputation which has been achieved in this realm of scientific research by those who have been associated with Gilmorehill. The provision is somewhat belated, as will be appreciated by anyone who has seen the present suite of apartments devoted to this important aspect of education: cramped rooms, some of them situated in the basement of the University, and most of them badly ventilated and lighted, lacking the essentials of up-to-date equipment for research work, and without the convenience which concentration and direct communication give. While the great scientific

departments in the Faculty of Medicine have within recent years been furnished with modern laboratories, zoology alone has remained in its somewhat antiquated accommodation in the north-east corner of the main building. It has no rooms built specially for laboratory purposes: it comprises a series of small rooms part of which formed the dwelling-house of the under-keeper of the museum. Yet it was in these rooms, badly lighted and insanitary, that much of the splendid work by Professor Agar upon heredity and by Miss Muriel Robertson on protozoology (to cite two examples which readily occur to the mind) was carried out. "Extreme difficulty" is a mild description of the conditions: indeed, the one fairly good room in the department, that which is used for the elementary class, is really a part of the museum which has been lent for the zoology work. The need for greatly improved accommodation has long been recognised, and practical steps would have been taken some years ago to provide it but for the intervention of the war, and the plan now about to be commenced will not only meet that recognition, but it will free a considerable portion of the north wing of the museum for general University purposes. The entire building scheme contemplated is much more extensive than the provision of new quarters for the zoology department, as it involves the erection of additional accommodation for the Faculty of Arts and the memorial chapel at the west quadrangle, but these sections of the scheme are meantime in abeyance.

EARLY DAYS IN THE DEPARTMENT

Agnes E. Miller

Though my acquaintance with the Department of Zoology did not take place until the winter session of 1917, there is on record a description of the building, its location and condition from the pen of Sir John Graham Kerr[1]. Writing in 1902, he states that "passing through Glasgow... I took the opportunity of making a reconnaissance of my future department. There was, of course, no zoological laboratory. The eastern half of the lower hall of the Hunterian Museum, known in later years as the Hunter Hall, had been used for what little practical work had been done, but it had no scientific equipment. Its floor was littered with geological debris; its entry was made by wooden steps through one of the windows." Incidentally this window may still be recognised as different in pattern from all the others on that north side of the East Quadrangle.

When I arrived to take the course in Zoology it was obvious that with the passage of time certain improvements had been made since that description of 1902. The large elementary laboratory was fitted with long wooden tables, with adequate if sometimes old-fashioned microscopes and individual electric lamps made to Professor Kerr's specification by Messrs Pye of Cambridge. Apart from the large laboratory the only room on the same plane was a passageway to the door of the lecture theatre, to a narrow stair leading up to an entresol which was the Professor's room and to another door opening on to an iron spiral stair to the basement. Down there were the research rooms, the windows of most of which were well below the level of the quadrangle so that only limited daylight penetrated; the other rooms had no windows at all.

Situated above the elementary laboratory and not very easy of access for the ordinary student was the zoological part of the Hunterian Museum. Here Professor Kerr had been at work re-organizing and re-arranging those specimens more useful for teaching. Again, it was lack of space that hindered their adequate display. It was, however, the necessity of preserving the various valuable Hunterian collections that seemed to rouse the University Court of that day to the growing importance of the subject. Space was not the only thing lacking, for the University Court had no available funds to finance such necessary improvements. However, the Bellahouston Trustees[2] agreed to supply a sum of money for the purpose, on condition that the Court provided a similar sum.

The active growth and development of the Museum coupled with a great increase in the number of students made more and more urgent the problem of accommodation for the Zoology Department as a whole. Accordingly, in September 1912, Professor Kerr had an interview with the University Court who regarded the situation with sympathy and discussions took place with the eminent architect, Sir John J. Burnet[3]. It was agreed that an entirely new building adapted to the needs of teaching and research should be provided and a site was chosen. The new Zoology building was to occupy the south side of a new quadrangle with the already existing Natural Philosophy building on its eastern side and the contemplated Chemistry building along the northern side.

The concentration of accommodation for research and practical classes along the north front ensured the steady northern light essential for microscopic work and dissection. A further precaution to supply adequate lighting for the elementary class was taken when the windows were carried right up through the full height of the building. Then came World War I when matters were delayed, but in July 1919 a beginning was made. There had been a suggestion that Sir Ray Lankester[4] might lay the foundation stone but by this time he was too infirm to undertake the journey. As the building took shape and its handsome proportions became recognizable there were those who wondered that so fine an edifice should have been erected for mere zoological requirements! In a conversation with Professor Graham Kerr on the design of the building, he said that his idea had been to have a two-storied factory type structure to which additional floors might be added as required for future developments. However, certain members of the University Court of earlier days who had strenuously opposed a new Department for Zoology, now declared that a worthy building must be provided.

In June 1923 the new building appeared to be almost complete and preparations were got in train to transfer fittings and equipment from the old Department.

However, on the day before the first lecture of the new term Professor Kerr looked into the lecture theatre and found NO BENCHES! Nevertheless, the lecture was delivered next morning with the students all sitting on the floor and all ready for fun. The lecture ended five minutes before time: the Professor then wrote a telephone number on the blackboard, and then made some remarks about contractors whom no one seemed to appreciate as they imagined they should be, but anyone with access to a phone might assure them that some were very much interested in their efforts. History records that the students played up and the contractors' phones rang from morning till night for an entire week.

The Museum was perhaps the most imposing part of the new building. It was indeed a great architectural success both as regards suitability for its purpose and its artistic beauty. It made a wonderful setting for the Rectorial luncheon on the 12th of December of that year when Lord Birkenhead[5] delivered his famous speech which was to upset many of the idealists gathered there and many others elsewhere. The style of building was so different from all those surrounding it that it appealed to many visiting the University (Fig. 1). Indeed, one professor in the Faculty of Arts brought regular parties of viewers to admire it: when, however, additions were made which spoiled the original symmetry these professorial tours ceased.

Any account of former days in the old Department would be incomplete were there no mention of two worthies who seemed woven into its fabric: Brannigan, the more conspicuous and Jamieson who was seldom seen (Fig. 2). The tall thin figure of Brannigan - he was an ex-Life Guardsman - was a familiar sight to all the first-year students as he brought in a glass of water a few minutes before the Professor entered to give the lecture. This was the occasion for quips and jests of all kinds but more often there was such hearty good-going singing that any other utterance was drowned in the chorus.

Brannigan combined many duties; for one thing all the work of preparation for the large practical class was carried through by him assisted by one boy only and since there was no other place, this was done in a corner of the elementary laboratory. Many of the specimens which had to be stored were here on shelves and when examination time drew near, parties of anxious students begged Brannigan to demonstrate those particular exhibits on which they might be questioned.

Fig. 1. The Graham Kerr (Zoology) Building. (A) Front. (B) North side. (C) Stairwell. (D) Empty museum. (Photos: T. & R. Annan and Sons for the University of Glasgow)

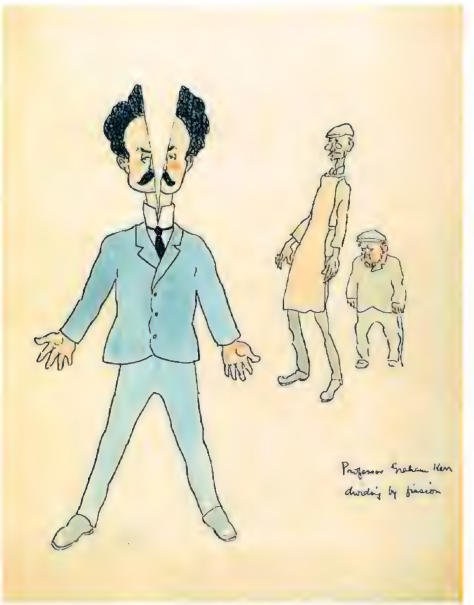

Fig. 2. Cartoon of Professor Graham Kerr "dividing by fission" with his two technicians, the tall Brannigan and short Jamieson. Drawn by Osborne Henry Mavor, better known as James Bridie, the playwright and founder of the Citizens Theatre. Mavor graduated in medicine in 1913, so would have been taught by JGK. He contributed caricatures of academic staff to the Glasgow University Magazine 1906-1913.

He also kept a firm check on the register of attendance both for lectures and practical class, which he sometimes, lapsing into army jargon, referred to as the "crime sheet!" His chief function became that of guarding the Professor from unsuitable callers and at this he was adept. He even watched those acquaintances who might waste too much professorial time and with his Irish charm he would adroitly speed them away.

Now Jamieson was the opposite of Brannigan in almost every way. He was, due to some accident in early life, very bent and small and cared not at all about his appearance. He was a well-read man and could argue with knowledge on many subjects but above all he was the most highly skilled section-cutter of his time. In his early days he had been employed in various laboratories in Edinburgh University and spoke of his work for Professor Rutherford[6] of Physiology, though it was in the department of Professor Cossar Ewart[7] that he met Graham Kerr, then a medical student. When Professor Kerr came to Glasgow, he had much *Lepidosiren* material to work up, so he began to look for Jamieson who seemed to have disappeared. Ultimately, he was located and set to work. The University Court did not agree to pay this technician, so the Professor paid him four pounds a week for about ten years or so until Professor Bryce took up the matter. It was no secret that shortly after he had produced some beautiful work a very distinguished member of the medical faculty offered Jamieson three times that amount if he would go and work for him. However, Jamieson, who did not have a gentle tongue, gave what some would call a "dusty" answer.

These two personalities never agreed: Jamieson teased Brannigan whom he considered inferior in intellect and Brannigan could not always conceal his contempt for Jamieson's slovenly ways. The one bond that held them was their complete loyalty to their chief. The move to the new Department affected these two more than any of the others. Brannigan, immured in an office albeit fitted with glass all round, no longer could visit the specimens with the students and the large airy room in which Jamieson was now placed was too bright and clean compared with the dingy, homely corner he had left.

Many were the personalities who passed through Zoology in the old Department and who attained fame all over the world. It might be interesting to mention one, a medical student, who was called to become Chancellor of his old University and whose name is fittingly remembered in the new large Boyd Orr[8] building.

1944-1964

Sir Maurice Yonge, F.R.S. (Fig. 3)

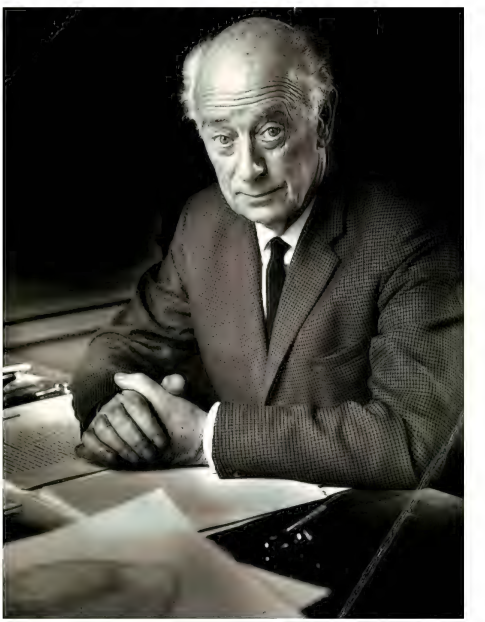

Fig. 3. Sir Maurice Yonge. (Photo: Department of Zoology Archives/University of Glasgow)

I have been asked to provide some record of the Department during the 20 years, from October 1944 to December 1964, while it was under my charge. I am uncertain about dates, but the sequence of events is probably roughly correct.

The war was nearing its end when I arrived, but conditions could hardly have been more depressing. The staff consisted of Charles Parsons[9] who had been in charge since my predecessor[10] left the previous January and no one could have wished for a better senior colleague, Otto Lowenstein[11] later to go as Professor to Birmingham, Dr. Margaret Jepps[12] a distinguished protozoologist whose health compelled retirement after a few years, and Nora Miller[13] still very much with us. Later Anthony Downes[14], lecturer in Entomology who later went to Canada, J.D. Robertson[15], now occupying a personal chair, and Harry Slack[16], now recently retired from his labours in Loch Lomond, returned from national service. I had made one condition when I came, namely that Hugh Steedman[17] should follow me to Glasgow which he did in 1945. He had been my right hand at Bristol and so was to be in Glasgow where staff and research students gained immeasurably from his unique wealth of technical knowledge.

I had come from a new building, actually completed after the outbreak of war, with sizeable advanced classes; in Glasgow I found a building designed as though the needs of 1923 were those of eternity and with only two students beyond first year, namely L.H. Finlayson[18] and W. Russell-Hunter[19], the one now in a chair at Birmingham and the other at Syracuse, N.Y. So at least the quality could hardly have been better. I was to struggle with the building for the next 20 years, few of them passing without some operation involving subdivisions of rooms, breaking through massive walls or opening up new areas in the extensive but initially almost unusable basement.

The first necessity in teaching was to extend the honours course from 3 to 4 years and hope to attract students into the advanced years although these never exceeded the numbers reached in Bristol before the war. Matters are very different now. A great deal depended on the first-year teaching and I continued to give the introductory lectures until a few years before I resigned the chair.

The first development was the building of the extension for agricultural zoology. This was, I think, the first building erected by the University after the war and its connection with the main building involved cutting through something like three feet of solid masonry. It did have the added advantage of opening up the blind end of the basement letting in air and some light and permitting its gradual utilisation. Alec Hill who was responsible for teaching in agricultural zoology with his colleagues, first Alistair Fraser, and later Ronald Dobson and Douglas Cochrane, was able year after year to attract excellent students into the honours course[20].

Loch Lomond came early into the picture. Harry Slack was anxious to develop freshwater biology, while money came from governmental and private sources for a programme of research into midges (*Culicoides*), this under the general direction of Douglas Kettle, not a member of staff but a very welcome guest, with assistants including Bill Lawson who remained to succeed Downes. Accommodation for both activities was provided in two large ex-army wooden huts erected, by the generosity of Sir Iain Colquhoun, on his property at Luss[21]. A converted lifeboat was bought at Balloch, later replaced by a motor-boat purchased at Leith, and brought across through the Forth-Clyde canal and up the Leven.

About this time the U.G.C. offered the University a lectureship in taxonomy which led to the appointment of Roy Crowson[22]. When the Veterinary College was taken over this involved the transfer to the department of Adrian Hopkins[23] who was to teach parasitology and do research in experimental helminthology. This led in 1963 to a grant from the Wellcome Trustees for the erection of a laboratory for Experimental Parasitology at Garscube (Fig. 4).

Fig. 4. The Wellcome Laboratories for Experimental Parasitology, Garscube (Photo: Department of Zoology Archives/University of Glasgow)

To turn to personal concerns, I spent the greater part of 1949 as Visiting Professor at Berkeley, California; I did not accept the offer to remain permanently but did have a most invigorating period of molluscan research at Pacific Grove during the summer. This visit resulted in the later exchange between Ralph Smith of Berkeley and Bob Clark[24] then an Assistant, later to go to Bristol and now Professor at Newcastle. Arthur Clarke[25] a fellow Assistant is now Assistant Keeper of Natural History at the Royal Scottish Museum.

Charles Parsons ran the Department in my absence and it must have been in the following year that, with tragic suddenness, he died, a major loss to everyone. He was succeeded as Senior Lecturer by Otto Lowenstein and as Lecturer in charge of Medical Students by the appointment of Anthony Barnett[26] whose ethological activities, later assisted by provision of facilities in the basement, were to continue until he moved to the Chair of Zoology at Canberra.

The field of insect ecology was graced by Mike Brian[27], a person of notable silences but great research acuity who left to take charge of the Nature Conservancy research station at Furzebrook. With interest moved from ants to aphids, research in this field was later developed by Tony Dixon[28], again with provision of special facilities in the basement.

Otto Lowenstein, pupil of Von Frisch, had been engaged in the study of behaviour and of neuro-physiology before I arrived. After his departure this was continued by Graham Hoyle[29], a stimulating if not always easy colleague, who was to move as Professor to Eugene, Oregon. He was succeeded by his junior colleague, Peter Usherwood[30]. With the erection of the new buildings for parasitology, the block containing the animal houses became vacant and was reconstructed internally to provide a surprising amount of accommodation for Peter's activities which here continued to flourish until their recent move into the main building.

The elementary laboratory as built and still existing in 1944 could have been claimed as the most magnificent in Great Britain, perhaps in Europe. It had an impressive floor area and rose the full height of the building seeking additional light (dubiously obtainable in a Glasgow autumn or winter) by way of extensive north-facing skylights. The greatest internal alteration during my tenure was the conversion of this single room by horizontal and vertical divisions into, on the ground floor, a somewhat smaller elementary laboratory, a small lecture theatre and a preparation room (neither present in the original building); on the first floor two advanced laboratories, a research laboratory, a further preparation room and a balance room. The one-time tank room that had housed *Lepidosiren* had already been converted into an experimental laboratory where J.D. (Robertson) taught, while the small advanced laboratory was converted into three staff rooms. Teaching could now be removed from the floor of the Museum, and the inevitable process of peripheral subdivision of this impressively pillared hall began during my tenure to be later, I believe, much extended.

Harry Slack's activities on Loch Lomond led to requests for a permanent laboratory on what is probably the best site for research in fresh-water biology in Scotland. Eventually the University agreed and after much helpful discussion with Stirling C.C. planning authorities a mutually acceptable building was erected south of Rowardennan (Fig. 5). It was officially opened the year after I left so that only its inception and erection are my concern.

My personal interests are marine and molluscan. From 1944 to 1967 I was Chairman of the Executive Committee and then President of the Scottish Marine Biological Association and intimately concerned with the Millport Laboratory. Although conveniently placed for Glasgow, and all marine activities of the Department took place there during my time, Millport[31] was a most unsuitable site for a research institute and my major concern over these years was to move the laboratory, in the event to its admirable position at Dunstaffnage.

Gareth Owen[32], Russell Hunter, John Allen[33] and Alan Ansell[34] (I could add Dan Quayle from Nanaimo, B.C.) were all concerned with molluscan research and with Millport. Gareth came with a grant from the Development Commission to assist me and later became a most valued member of staff, now Professor at Belfast.

Fig. 5. The Zoology Field Station, Rowardennan, Loch Lomond. (Photo: Department of Zoology Archives/University of Glasgow)

I would go to him with a bright idea and he would soon be back with a brighter one. My personal research owed much to him and to Hugh Steedman. All the four mentioned above were to receive John Murray Travelling Scholarships[35] from the Royal Society and to visit New Zealand, the United States, Jamaica and elsewhere. But I think all the lecturers went overseas for research experience, while my membership of the then Colonial Fisheries Advisory Committee led to Harry Slack spending a year at Malacca and Hugh Elder[36] a longer period at Jinja in Uganda. Amongst my final activities was the installation of the A.E.I. E.M.6 [transmission electron microscope] in rooms especially constructed out of a former store in the basement. Preliminary enquiries were made by Hugh and Gareth who both attended a course on electron microscopy in Sweden. Indeed the facilities as I left them at the end of 1964 (and reported anonymously in *Nature* 205, 745-747) did then seem to represent all that could have been done in the period. It amazes me how much more has been achieved during the eight years since I resigned.

I had a further year away as Visiting Professor at the University of Washington, Seattle, and then at Pacific Grove in 1959/60 but returned to become Dean of Science, a position I had held at Bristol for 4 years. Research effectively ceased. I took the first term of 1964 off to visit Tom Goreau[37] (with whom I was to work closely until his death in 1970) in Jamaica and to lecture in the United States. I had hoped this would restore academic interests but, after 30 years, I had had enough and, with the deeply appreciated help of the Principal was able to resign and assume the welcome status of Research Fellow on January 1st 1965. A few days later I left to join the Stanford University research vessel *Te Vega* at Singapore.

I have recorded my particular indebtedness to certain colleagues: I would like to add Mary McDill, most admirable of secretaries who corrected so many of my errors and repetitions; Alec McKinnon, chief technician, and Jan Campbell for ten years, five before resignation, an invaluable, and still much missed, research assistant[38].

FROM 1965 TO 1973 AND BEYOND

D.R. Newth[39] (Fig. 6)

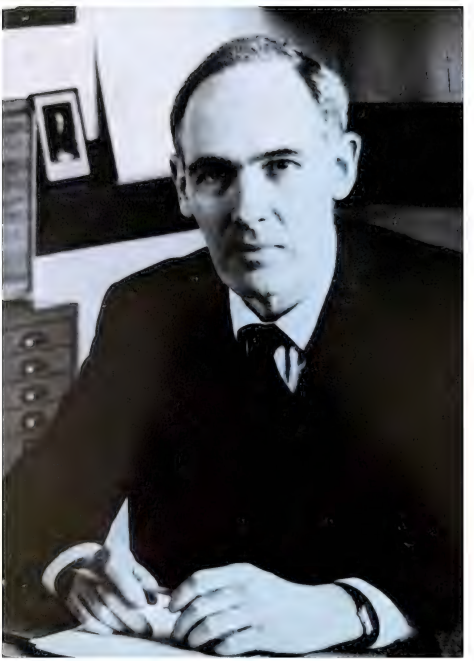

Fig. 6. Professor David R. Newth. (Photo: From the personal collection of Pat Monaghan)

In 1965 the department was, in many ways, well placed to meet the challenge that the sixties brought to established biological departments. Its size and width of interests made a broad curriculum possible for undergraduates, and the heavy commitment to medical, veterinary and agricultural teaching meant that the social relevance of biology was part of its everyday business. The new field station provided excellent opportunities for work in limnology and the parasitologists were housed in new laboratories, though at the expense of a three-mile separation from Gilmorehill. The chief problems of the department were to exploit its academic advantages in the interests of more than a handful of advanced students, and to find answers to the difficulties of teaching an ever more crowded curriculum in an ever more crowded building.

Since 1965, each year has brought major changes in teaching, in research, or in physical amenity, and in each case the change has been associated with growth. In research two groups of importance arose: in electrophysiology around P.N.R. Usherwood, and in aphid biology around A.F.G. Dixon. The Nuffield Foundation made the resurrection of one of the department's old strengths possible by supporting a group in experimental protozoology under K. Vickerman[40]. The Science Research Council, the Agriculture Research Council and the Leverhulme Trust sponsored a group in developmental biology under D.A. Ede[41]. Mention should also be made of the collaboration with the department of education in work for the Nuffield Foundation Inter-University Biology Teaching Project[42].

In teaching, one of the main changes has been the introduction of the biology course for first year science students which replaces the old botany and zoology courses, and the move of this class, and all first year teaching, to the Boyd Orr building. This has meant some modification of second year teaching, but the major innovation has been in the third year which is now largely devoted to optional courses. This has allowed an element of student choice, has kept classes to a smaller size, and has allowed more time for teaching in particular fields, but at the expense of producing graduates who have not studied the whole of zoology to an equally advanced level.

If there is a philosophy behind these developments it is that modern science often demands group research and teaching, but that the fragmentation of large biological departments into small ones is a mistake. In the first place there will be individuals whose work does not call for team organisation, and only a larger general academic unit can happily support them. In the second place, freedom of movement for individuals should be made easy so that an early undergraduate enthusiasm for physiology can easily give way to a later enthusiasm for parasitology, which may change again to a graduate enthusiasm for ecology. In a large general department such transitions are not difficult to make. Finally, one must hope, though against the evidence in many cases, that our specialists learn from each other, whether at research colloquia or at coffee.

The last eight years have seen a striking growth in student numbers - the higher ordinary and honours classes have quadrupled in size and graduate student numbers have doubled. To accommodate them and to improve the laboratories, a continuing programme of additions and conversions in the building has been undertaken. The major changes have involved the construction of a laboratory floor on the roof of the museum (Fig. 7), the conversion of part of the museum to research and teaching rooms, the construction of a small experimental animal house, and the upgrading of old junior teaching laboratories for senior classes. If Graham Kerr could return after 50 years he would see little but the main lecture theatre that he could easily recognise.

Without these changes the department would have been unable to meet its commitments, but even with them some of its units (developmental biology and programmed learning) have had to be exiled to other buildings (Fig. 8).

There are, of course, also personal matters to report. Maurice Yonge stayed in the department from 1965 to 1970 as a research fellow and then withdrew to Edinburgh. His knighthood, conferred in 1967, gave

Fig. 7. The Zoology Building from above, showing the original roof laboratories. (Photo: Department of Zoology Archives/University of Glasgow)

Fig. 8. The Developmental Biology Building, Horselethill. (Photo: Department of Zoology Archives/University of Glasgow)

pleasure to all who had worked with him. S.A. Barnett moved to the chair in the Australian National University in Canberra after twenty years during which he had contributed much to several of the department's activities. H.D. Slack, having nursed the new field station through its infancy, retired, but to a place from which he could continue to keep an eye on it. Promotions to Senior Lecturer have overtaken R.A. Crowson, A.F.G. Dixon and P.N.R. Usherwood, while C.A. Hopkins lost his amateur status on appointment to a titular professorship.

The department has been fortunate in its collaborators in this period. The botanists, who share responsibility for first year classes with it, now also join us in teaching a second year course in Applied Biology. The geneticists and the immunologists are teaching honours students in zoology. The Beatson Institute provides teaching in some honours courses. Our warm relations with the Scottish Marine Biological Association have survived their move to Dunstaffnage, while the department is glad to have the services, as honorary lecturers, of the academic staff of the University Marine Station at Millport.

The department can look forward to the next fifty years with some confidence. The policy of concentrating upon a few major areas for research and teaching, while not excluding work in others, is only practicable for a large school. It must necessarily be the pattern of choice for university organisation in biology, and it means that further growth of the department is to be welcomed.

STUDENT LIFE IN THE DEPARTMENT

J.R. Downie

In the early days, the number of students was much smaller than today. The first record of a student society pre-dates both the new building and even the separate existence of a Department of Zoology. It having been determined early in 1892 "that it was advisable a Natural History Society should be formed in the University," a meeting was held on 23rd March of that year to draw up that first necessity of all societies, a constitution. The Society existed to promote "the study of Natural History by organising field excursions and demonstrations." From the first, the demonstrations were successful, and the excursions less so; and even in those far-off days, the weather was to blame. These were days of unity in the biological sciences. A single demonstration included rocks and an astonishing array of bits of animals - whale skin, walrus ivory, a whale earbone, and sections of the eye of a snail, the jaw of a rat, a kitten and a mole. The Natural History Society enjoyed a brief life, and a few years later, Graham Kerr became Regius Professor of a separate Department of Zoology.

We owe to Sister Monica Taylor, for many years head of biology at Notre Dame College, a reminiscence of a zoology student's life in the old building, before the First World War. Graham Kerr gave most of the lectures himself at 9 a.m. (a tradition surviving in the present time-table) in a course dominated by evolutionary morphology. Students were then left to fend for themselves with a mass of material from the Hunterian Museum. Women students at that time were generally taught separately, in Queen Margaret College[43] (now headquarters in Glasgow, of the BBC), but not in Zoology, where men and women were together because of the problems of moving practical material.

Despite the building, a dark Gothic barn of a place, there was a great family spirit in the small department. Staff and students had tea together in Graham Kerr's rooms, and there was considerable excitement as staff members were often fitting out and setting off on expeditions to exotic lands. The high point of each year was Graham Kerr's kaleidoscopic lecture on his Grand Chaco experiences[44], which apparently held all listeners spellbound for as long as three hours. A partisan rather than objective atmosphere pervaded the Department. Students were plunged in gloom when Ross Harrison published a decisive refutation of Graham Kerr's views on nerve fibres; and roused to jubilation when Kerr emerged from his study to argue (wrongly as it turned out) that Harrison's work in fact reinforced his theory[45]. Graham Kerr encouraged the founding of a small zoological society and gave the inaugural lecture

himself. The Society lapsed during the War, but re-appeared in 1923, with the transfer to the new building. Records of the Zoological Society exist from 1926. Membership was in the 40's or 50's, the majority being medical students, and from the earliest days, meetings, about six per session, concentrated on the social relevance of biology. Joint meetings with Botanists and Geologists were commoner than now, as were undergraduate papers (half of the total in some years). It is sad that today's crowded curriculum allows students less time to prepare their own original papers.

Meetings that catch the eye include a joint debate with the Botanists against the Physicists in 1933: "That scientific progress in the future will be biological rather than physical ". Biology won: a Brains Trust in 1942, aping the popular war-time BBC radio programme; and a prototype of University Challenge, on biological subjects, arranged by Dr. Lowenstein, also in 1942.

An annual highlight was the Scottish Universities Biological Conference, the first reference being to a meeting in St. Andrews in February 1927, chaired by D'Arcy Thompson. At first, these attracted small numbers of students to demonstrations and lectures by academic staff; but over the years, staff participation waned, most presentations were by students, and the social element increased. Numbers of Scottish biology students were so small during the Second World War that when the conference met again in St. Andrews in 1944, all the visiting delegates were able to stay at D'Arcy Thompson's home.

After the War, an innovation was the Scottish Universities Touring Speaker: two eminent biologists were invited annually to lecture to all four of the old Universities. The event attracted Alister Hardy, Maynard Smith, Sir Peter Medawar[46] and many others. More recently, with the expansion in numbers of Scottish Universities, and drifting apart of the various biological sciences, this event became a burden to everyone and was abandoned in 1969.

The Zoological Society has always been a focus for social activity in the Department, not always with success. A constant complaint of secretaries was the failure to attract medical and elementary students to Society events. The failure of one dance was blamed on the deadly combination of a Wednesday night, and Queen Margaret Union. The social aspect boomed in the middle 60s with a rise in membership from a usual 100-200, to the astonishing 493 of 1967-68, when the Zoological Society was almost the largest in the University. Meetings were weekly. not fortnightly, and dances, debates and sporting outings were all successful. Membership has declined since, with the departure of all elementary classes to the Boyd Orr Building, but the Society continues to be a strong centre of social activity in the department[47].

APPENDIX

Superscripts in the text refer to the numbered notes below. In some cases, notes refer to other articles in this volume. Where these refer to JGK's memoir, *A Gallery of Memories*, the note simply reads "See *Gallery*". Where the reference is to the article *The Flourishing of Glasgow Zoology*, the note is "See *Flourishing*". Where the text mentions something or someone more than once, the superscript is not repeated. Sources of information in the notes include the online encyclopaedia Wikipedia, and obituary or perspective articles.

1. See *Gallery*. JGK wrote more on this in his memoir.
2. See *Gallery*, note 92.
3. See *Gallery*, note 94.
4. See *Gallery*, note 29.
5. See *Gallery*, note 96.
6. See *Gallery*, note 10.
7. See *Gallery*, note 14.
8. Lord John Boyd Orr (1880-1971); Ayrshire-born University of Glasgow biologist (1910) and medical graduate (1912). Distinguished career in nutritional research and action, becoming Director-General of the United Nations Food and Agriculture Organisation after World War 2. Awarded Nobel Peace Prize 1949; later ennobled. Served as both Rector and Chancellor of the University of Glasgow (the editor recalls being "capped" by him at graduation in 1967).
9. Charles Parsons (1901-1950); studied at Cambridge, then lectured at Glasgow until his sudden early death.
10. Edward Hindle, F.R.S. (1886-1973); Regius Professor of Zoology at Glasgow 1935-1943. Helped establish the Glasgow zoological gardens at Calderpark, and became the first scientific director of London zoo on leaving Glasgow. Known for research on insect-borne diseases such as leishmaniasis and yellow fever.
11. Otto E. Lowenstein (1906-1999); German Jewish zoologist: moved to U.K. in 1933 for further study; on staff of Glasgow Zoology 1938-1952, then Professor at Birmingham. Research on hearing in fish.
12. See *Gallery*, note 106.
13. See *Gallery*, note 108.
14. John Anthony Downes (1914?-2003); Entomologist who specialised in Diptera. Studied zoology at Imperial College, starting on the same day as Roy Crowson (note 22). Lectured at University of Glasgow 1940-1953, then moved to the Canadian National Insect Collections, Ottawa.
15. James D. Robertson (1912-1993); Glasgow-born zoologist; first degree University of Glasgow, Ph.D. Cambridge, then lecturer, professor at Glasgow until retirement. Research on physiology of aquatic vertebrate body fluids and their bearing on vertebrate evolution.
16. Harry D. Slack (1907-1982); grew up in Derbyshire; studied zoology at the University of London; Ph.D. Edinburgh; lectured at the University of Glasgow 1937-1972. Carried out extensive research on the ecology of Loch Lomond, and was instrumental in the foundation of the Loch Lomond field station(s).
17. Hugh F. Steedman (1907-1991); lectured at Glasgow 1945-1964. Best known for his work on microscopical techniques, especially section-cutting and preservation methods.
18. L.H. Finlayson; Glasgow zoology graduate 1945; insect physiologist. Progressed to become professor at Birmingham from 1965.
19. W. Russell-Hunter (1926-2005); Glasgow graduate 1946, then Ph.D. and D.Sc. by 1962. Lectured at Glasgow 1947-1963, then moved to Syracuse University, New York state. Researcher and writer, including influential textbooks, on marine and freshwater invertebrates, especially molluscs. Remained a member of Glasgow Natural History Society until his death. Obituary by Peter Maitland, *The Glasgow Naturalist* 26(4), 165-166 (2006).
20. See *Flourishing* for an account of the Agricultural Zoology degree and staff.
21. Sir Iain Colquhoun (1887-1948); Laird of Luss and chieftain of Clan Colquhoun. A First World War hero, but also known for being court-martialled after agreeing with German officers to a Christmas truce in 1915. Rector of the University of Glasgow 1934-1937.
22. Roy A. Crowson (1914-1999); lectured at Glasgow from 1949 and continued research-active until his death. Evolutionary biologist and insect systematist internationally-renowned for his work with Coleoptera. Produced a higher classification of beetles based on anatomical and larval characters, rather than simply on external morphology. This work used the Hunterian Museum's collections, and many specimens from his own fieldwork around the world (much of it assisted by his wife Betty, a University of Glasgow zoology graduate). The latter collections are housed in the Hunterian Museum and the NHM (London). Many new taxa were named by him, and in his honour, such as the monotypic genus *Crowsoniella*. His massive *Biology of the Coleoptera* (1981) became a standard work on the subject.
23. Glasgow Veterinary College was founded in 1863 and allowed training of veterinary surgeons qualified to register with the Royal College. The College was merged with the University of Glasgow in 1949, and became a Faculty in 1968. A new veterinary hospital and research facility was built at Garscube estate on the northwest edge of the city in the 1950s, with teaching facilities added later. Parasitologist Adrian Hopkins became a member of the zoology staff from 1949. See *Flourishing* for more on him and parasitology at Glasgow.

24. R.B. Clark (1923-2013); lecturer at Glasgow 1950-1956; later at Bristol, then professor at Newcastle from 1965. Worked on structure/function of annelid worms, culminating in his book *Dynamics in Metazoan Evolution* (1965) which drew on his early studies in mathematics and physics. In Newcastle, actively involved in the natural history of the northeast, and research moved into the field of marine pollution. He served on the Royal Commission on Environmental Pollution. Obituary by Olive & Hutchings, *Memoirs of the Museum of Victoria* 71, 361-366 (2014).
25. Arthur Clarke: no retrievable information.
26. Samuel Anthony Barnett (1915-2003); studied zoology at Oxford. In World War 2 advised the U.K. government on rats and plague. Lectured at Glasgow 1951 to 1971 as first animal behaviour specialist. Became professor at Australian National University, Canberra 1971-1980. Prolific author of books on behaviour, evolution. At Glasgow, worked on the adaptations of small mammals to cold. Had radical ideas on education: the editor recalls Barnett's "free group discussions" on concepts like instinct, consciousness and adaptation with awe.
27. Mike V. Brian OBE (1919-1990); lectured at Glasgow 1946-1953. Became officer in charge of the Furzebrook ecology research station, 1953-1982. Entomologist, ecologist, lifelong student of social insects. Obituary by Elmes & Stradling, *Insect Societies* 38, 331-2 (1991).
28. Anthony F.G. Dixon ; lectured at Glasgow from 1957; moved to the University of East Anglia as professor. Researcher on the ecology of aphids and other insects.
29. Graham Hoyle (1923-1985); neuroscientist and comparative muscle physiologist. D.Sc. and lecturer 1952-1959 at Glasgow; moved to the U.S.A. and was professor at the University of Oregon till his death. Perspective article by Medler (2023), *Advances in Physiology Education* 47, 893-903.
30. Peter N.R. Usherwood; Ph.D. (1960) and Lecturer at Glasgow (from 1960) working with Hoyle on insect neuromuscular systems. Left to become professor at Nottingham 1974.
31. Millport: see *Flourishing* for an account.
32. Gareth Owen CBE (1922-2002); Welsh zoologist. Lectured at Glasgow 1950-1964, then professor at Queen's, Belfast 1964-1979; Principal of the University of Wales, Aberystwyth 1979-1989. Research on the functional morphology of brachiopods and bivalve molluscs, using electron microscopy.
33. John A. Allen (1926-2020); lectured at Glasgow 1951-1955, and was later Director (1976-1991) of the University Marine Biological Station, Millport, where he again helped teach Glasgow students. Research on deep sea ecology, especially of bivalve molluscs.
34. Alan D. Ansell (1934-1999); Ph.D. (1959) and lecturer at Glasgow 1959-1961. Worked at the Scottish Association for Marine Science (SAMS, Oban) 1969-1999 on molluscs, especially bivalves.
35. John Murray; see *Gallery*, note 15.
36. Hugh Elder; Glasgow zoology B.Sc. (1959), Ph.D. (1972) and lecturer 1962-1966. Moved to Glasgow Physiology department as an electron microscopist.
37. Tom Goreau (1924-1970); marine biologist, working especially on coral reefs around the Caribbean. Died of cancer following exposure to radioactive samples collected at the American atomic bomb testing site at Bikini atoll, Marshall Islands.
38. Mary McDill began her secretarial career in Zoology in 1951, progressing to become principal secretary, indispensable to successive regius professors. Alex McKinnon was a technician in Zoology 1914-1964, latterly as chief technician, another indispensable part of an efficiently run department. Jan Campbell (later Meadows) graduated B.Sc. in zoology in 1955, and became research assistant to Professor Yonge. After his departure, she became assistant to lecturer Peter Meadows, whom she married. She co-authored the book *An Introduction to Marine Science* (two editions: 1978 and 1988) with Meadows. They later divorced. Jan Meadows acted as administrative co-ordinator of the Biology-1 course from its inception in 1969.
39. David R. Newth (1921-1988); studied Zoology at University College London; after war-time service, he became a lecturer there, then inaugural Professor of Biology as Applied to Medicine at Middlesex Hospital Medical School in 1960, and Regius Professor of Zoology at the University of Glasgow from 1965, retiring through ill health in 1981. He was a specialist in developmental biology, serving as President of the British Society for Developmental Biology and second editor of the Journal of Embryology and Experimental Morphology for 10 years. He also had wider interests, being President of the Scottish Marine Biological Association and a council member of the Nature Conservancy Council.
40. Keith Vickerman (1933-2016); born in Huddersfield, an enthusiastic naturalist from an early age, especially keen on tiny organisms requiring a microscope for observations. Zoology degree at University College London, Ph.D. Exeter then back to UCL as a protozoologist. Research on sleeping sickness (trypanosomiasis) began his major life's project on life history changes in parasites and especially the antigenic variation that allowed them to evade the host's immune response. Moved to Glasgow 1968; Regius Professor 1984-1998; elected FRS 1984. Post-"retirement" research on soil protozoa and a new parasite of scampi. Keen gardener: served as President of Friends of Glasgow Botanic Gardens. Obituary by Cox (2017), *Parasitology* 144, 1-3.
41. Donald A. Ede (1926-2018); developmental geneticist, especially interested in vertebrate limbs. Moved from the Genetics Department of Edinburgh University in 1972 to head the new Glasgow developmental biology unit. Pioneer of the use of computer simulations. Retired 1998.
42. Nuffield Teaching project: see *Flourishing*.
43. Queen Margaret College began as North Park House, 1871; bought by Isabella Elder in 1884, and became a College for Women, 1892 and part of the University. From 1936-2007, it was headquarters of the BBC in Scotland. After

their removal to Pacific Quay, extensive demolitions returned the build to more like its original, and it became headquarters of the G1 restaurant group.

44. See *Gallery* for JGK's Gran Chaco experiences.
45. In the early 20th century, there were two opposing theories on the origin and structure of nerves: a) nerves were syncytial structures formed from the fusion of glial cells; b) nerve fibres extend by growth/movement from early nerve cell bodies. The great cell biologists Golgi and Cajal were on opposite sides of this debate and argued their different cases in the lectures given after their joint award of the Nobel prize for physiology in 1906. JGK, with Golgi, favoured the syncytial theory. The matter was essentially settled by Ross Harrison, who grew isolated spinal cord fragments from frog embryos, inventing the procedure of sterile tissue culture to do so. He observed the "growth cones" of individual neurones moving out of the fragment by a process like amoeboid movement, with the long thin axon extending as the growth cone moved out. The observations were reported in a series of papers from 1906. The longest one in 1910 included a refutation of the criticism made by JGK in his Presidential Lecture to the Royal Physical Society of Edinburgh (Kerr (1910), *Proceedings of the Royal Physical Society* of *Edinburgh* 18, 1-20.). See Keshishian, H. (2004), *Journal of Experimental Zoology* 301A, 201-203 for an account of this debate and its resolution.
46. Sir Alister Hardy (1896-1985); marine biologist and artist, had been a camoufleur in World War 1. Wrote two much-read books in the Collins New Naturalist Series on *The Open Sea.* Worked at the universities of Hull, Aberdeen and Oxford. Known for a controversial theory on human origins, the aquatic ape hypothesis. John Maynard Smith (1920-2004); began his career as an engineer, but later switched to biology, specialising in studies on evolutionary theory. Wrote semi-popular book *The Theory of Evolution* for Penguin Books, and developed the idea of evolutionary stable strategies. Professor at University College London and Sussex. Sir Peter Medawar (1915-1987); Brazilian Lebanese in origin, but career in biological sciences in the U.K. Worked on the immunology of tissue transplantation, winning the Nobel Prize for physiology/medicine in 1960. Professor at Birmingham and University College London, then Director of the National Institute for Medical Research at Mill Hill; as well as publishing many scientific papers, wrote extensively on the practice and philosophy of science.
47. See the article by Downie *et al.* on *Student Initiatives* in the following section for more information.

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The Department of Zoology and the Hunterian Zoology Museum

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ABSTRACT

An account is given of The Hunterian zoology collections, focusing on their history, development, management, care and uses in teaching, research and exhibition from John Graham Kerr's time, in the early 1900s, to the present day. Over their 260-year existence, these collections have been housed in two cities and five different premises, and their curation and care has variously been shared between the Department of Zoology (formerly, in the 19th century, Natural History) and The Hunterian. John Graham Kerr passionately believed in the utility of museum specimens to support teaching in natural history. To this end, he ensured that a fine museum gallery with beautifully laid-out informative displays was a central feature of the new Zoology Building when it opened in 1923. One hundred years later, the profile of, access to, and use of the zoology collections are flourishing and the Zoology Museum retains its position as a valued teaching, learning and social space for Zoology, the wider university, and the public audience.

INTRODUCTION

The zoological collections of the University of Glasgow have a 260-year history and, since the arrival of the foundation collection in Glasgow in 1807, at various times have been in the care of the Hunterian Museum and/or the Department of Zoology. In brief, the collections have their origin with William Hunter (1718–1783), the London-based Scottish anatomist and doctor. He bequeathed them to the University of Glasgow and for much of the 19th century they were housed in the original Hunterian Museum at the University's previous site in High Street. With the University's move to Gilmorehill in the 1870s, they were rehoused in the grand halls of the Gilbert Scott building. Finally, in 1923, they were moved to the newly built Department of Zoology with its elegant museum hall where the zoology displays remain today. In 2007, some zoological displays were re-introduced to the Main Gallery of the Hunterian Museum. In 2016, the great majority of the collections were moved to a newly developed facility with modern storage and access at the Kelvin Hall, adjacent to the University campus.

William Hunter and his collections have been the subject of several recent publications (Brock, 1980; Bynum & Porter, 1985; Keppie, 2007; Hancock *et al.*, 2015; Campbell *et al.*, 2018) and so will be dealt with relatively briefly here. As this essay is intended to be part of the Zoology Building's centenary celebrations, it will focus more on the great contribution of John Graham Kerr (JGK) to the collections and fate of the museum to the present day. Collections are the *raison d'être* for a museum, and so a short account of the collections is provided first.

Superscript numbers in the text refer to notes in the Appendix. Unless stated otherwise, all of the images were either taken by the author or are from the Zoology Museum's archive and were probably taken by past departmental photographers. Older photographs taken by T. & R. Annan & Sons are so labelled.

THE ZOOLOGY COLLECTIONS

William Hunter's zoology collections housed in his private dwelling in London contained (as far as is known) around 7,600 pinned insects, more than 8,000 mollusc shells and, perhaps numbering in the low thousands, assorted other invertebrates and vertebrates from fish to mammals (including a stuffed adult elephant!). Today (2024) it is estimated that the Zoology collection numbers in excess of 600,000 specimens or specimen lots, representing all animal phyla, though 85% of that total comprises insect specimens. All forms of preservation are present – skins, bones, teeth, mounts, mollusc shells, pinned insects, other dry invertebrates, wet-preserved specimens, models, replicas, teaching charts, birds' nests and other animal artefacts, microscope slides, scanning electron microscope (SEM) stubs, frozen specimens and art works. The geographical spread is worldwide including, like many other museums, material from the colonial era, which is the subject of ongoing interdisciplinary investigations.

After their arrival in Glasgow, the Hunter collections were added to by donation, purchase, bequest and field work. It is standard museum practice (with legal implications) to record additions to the collections, usually in an accessions register[1]. However, very little on acquisitions was recorded over most of the nineteenth century, there being scant records for the whole museum for 1807–1820, almost nothing recorded for zoology between 1821–1878 and then from 1879–1899, midway through the era of the two John Youngs (see below), things pick up considerably with 405 recorded accessions of which 35% contain zoological objects, some of considerable importance.

The collections grew significantly through the late 19th

into the first half of the 20th century. The sale of private museums from the Victorian boom in scientific collecting enriched the holdings of many public museums at this time. Staff, students, alumni, professional contacts and local naturalists all donated specimens originating from field work, expeditions, surveys or research projects. Glasgow's citizens travelled widely and worked in many parts of the world and sent specimens home. Academic staff used their personal networks to acquire specific specimens. For example, JGK bartered some of his precious lungfish for various desirables such as rare caecilian embryonic material from Professor Brauer[2] in Germany, and deep-sea animals from the *Valdivia* expedition[3]. He received corals from the Smithsonian Museum's Thomas Wayland Vaughan[4], a leading coral scholar of the day, in return for photographs of the famous Ellis and Solander[5] corals found in Hunter's collection. The commercial supply of specimens flourished in response to the demand for professionally made, high quality preparations of all kinds for teaching and exhibition. Biological supply houses arose across Europe and in the U.S.A., such as Rowland Ward[6] and Gerrards[7] in London, Frič[8] in Prague, the Naples Marine Station[9] and Ward's of Rochester in New York[10], each becoming famous in their own right. All these suppliers are well represented in the Hunterian collections. Taxidermy was at its height in terms of spread and popularity. In Glasgow alone there were several taxidermy firms at this time, the most prestigious of which was Charles Kirk[11], supplying vertebrate mounts to private and public clients, including the Zoology Museum.

The flow of specimens into the museum, excepting entomology, reduced a great deal after World War 2 until the 1970s. However, many hundreds of accessions have been made since then. Some notable acquisitions include the comparative dentistry collection from the University Dental School (1994); specimens collected during University expeditions, especially those to Trinidad and Tobago led by Professor Roger Downie and ongoing since 1987 (arthropods, marine life, amphibians, reptiles); deep sea fish from the Porcupine Abyssal Plain research collection made by Zoology staff member Dr David Bailey and his PhD student Roseanne Milligan (2012); the Colley (2012) and Hammond (2014) private mollusc shell collections both with good quality modern data; Clyde Sea Area marine life, burrow casts and corals rehomed after the closure of the University Marine Biological Station Millport (2014); and from 1992 The National Nest Reference Collection[12], a research collection of British birds' nests initiated and assembled by Professor Michael Hansell as part of his life-long studies on animal building behaviour. This is an ongoing collecting programme, sourced from a network of U.K. ornithologists, for the museum.

THE ENTOMOLOGY COLLECTIONS

The entomological collections merit special attention. The number of described species of Insecta makes it the largest taxon in the animal kingdom[13]. Due to their popularity with collectors and as study organisms in the University and beyond, in addition to the size of the taxon, they are the largest group of organisms in the Zoology collections, amounting to an estimate of around half a million specimens. Most of the collection is pinned insects stored in drawers and boxes. There are also fluid-preserved specimens, microscope slide mounts, insect nests and artefacts, models, teaching charts and art. It is a scientifically important collection added to, curated by, researched and published on by in-house experts and their external collaborators. It attracts visiting researchers, and many loans are made to specialists across the world.

The first luminary to work on the collection was Johann Christian Fabricius (1745-1808), the Danish entomologist and pupil of Linnaeus, who was invited by William Hunter in the late 1760s to curate his collection. Hunter himself had no entomological expertise but amassed a superb collection with the help of Fabricius who described over 10,000 new species, of which several hundred type specimens are in Hunter's collection.

After the collection came to Glasgow, it languished throughout the 19th century largely ignored and endured what is now referred to as "benign neglect". Apart from the Graham Kerr incident described below, the Hunter insect collection, rather against the odds, survived into the 20th century relatively intact from pest damage, physical deterioration or human interference.

Nothing much was added to the collection in the 19th century – for example, between 1879 and 1898 there are only ten records for insects, all of which appear trivial. Robert Staig[14] joined the Zoology staff in 1903 as a teaching assistant and eventually became lecturer in charge of the entomology section and curator of the insect collections. There were monumental additions of the T. Bishop (1923) and the J.J.F.X. King (mid-1920s–1933) collections, each numbering in the hundreds of thousands. Several hundred other accessions are recorded throughout the twentieth century. In JGK's and Edward Hindle's time, donations in economic entomology, such as mosquitoes from Frederik Vincent Theobald (1868-1930)[15] and African pests from Alexander Cuthbertson (1901-1942)[16], were particularly useful acquisitions. Scientifically important additions by Zoology staff members, in the second half of the century, include Coleoptera from Roy Crowson[17] and insects of agricultural importance from Alex Hill[18] and Ron Dobson[19] and their associates and students. The collection continues to attract significant donations. For example, in recent years, the Pasteur collection of African butterflies (2005), the R.R. Moore collection of beetles from the Isle of Raasay (2017), the depositions by Dom Collins from his ongoing British Thysanoptera (Thrips) research, and the Highland insects collected by Brian Morrison, fisheries entomologist and former student (2023).

After Robert Staig's retirement in 1940, no specialist curator was appointed to replace him, though a number of dedicated entomologists joined the departmental staff

as researchers and teachers. Anthony Downes[20] worked with the collections after his appointment as lecturer in 1947. Roy Crowson was appointed in 1949 as lecturer in taxonomy and worked on and with the collections. Around the same time, Agricultural Zoology was developed as a departmental specialism and the staff were entomologists who researched and taught using the collections and cared for them *inter alia*. The Zoology Department provided some general technical help for routine collections maintenance such as adding pesticide (mothballs) to the collection. Research students and short-term contract staff also added to and looked after the collection in the absence of a dedicated curator.

In 1997, after the advent of Heritage Lottery Funding (HLF), a grant was secured to fund a two-year project (The Zoology Insects Project - ZIP) for an expert entomology curator to re-organise the over-crowded insect collections into new storage cabinets in additional space allocated by the Department. Included in the project was the creation of new public/teaching displays on insects – a serious lack in the existing provision. E.G. Hancock was appointed to the post in October that year. This was the most significant curatorial development in the insect collections since JGK's time and in recognition of the need, the project achievement and the opportunities generated, after the end of the project, the Hunterian established the entomology curatorial post. This was occupied until 2015 by Geoff Hancock who was succeeded by Jeanne Robinson, the current curator. The use, size, significance and international profile of the entomological collections continue to grow through the investment in these expert curators.

EARLY HISTORY – 18th AND 19th CENTURIES

William Hunter from Long Calderwood, East Kilbride entered the University of Glasgow as a young boy of fourteen to study for a degree in theology; he was the third son of a prosperous merchant farming family and the Church was seen as a suitable career for such a boy. However, he was "not suited" to these studies and left the University without a degree, becoming apprenticed to the doctor, William Cullen (1710–1790)[21], who was physician to the Duke of Hamilton. Cullen went on to a stellar career of his own, and William, utilising contacts in the Scottish medical network in London, served the rest of his apprenticeship there with distinguished physicians of the day. He set up a private anatomy school and medical practice specialising as a man-midwife. In time, as his professional reputation grew, he built up sufficient funds to indulge his passion for collecting which was a prestige activity amongst the educated and wealthy. His original specimens were those that served him in his teaching - anatomical and pathological preparations including comparative anatomy specimens. He had a discerning eye, money (though he was a shrewd negotiator) and high standards - his collection was wide ranging in arts, science and humanities, and was admired by his peers. He collected animal and plant specimens. The fate of his herbarium may be dealt with swiftly: it was last mentioned in the early 19th century and has not been seen since.

Hunter bequeathed his collections to his *alma mater* along with funds to build a museum to house them. He granted his nephew, the pathologist Matthew Baillie (1761-1823), the use of them for up to 30 years after his death. Hunter died in 1783, Baillie retired in 1800, the collections were shipped to Glasgow in 1805 and the Hunterian Museum opened in 1807. Hunter had instructed his trustees to draw up catalogues of all parts of his collection – for biological specimens, this was only carried out for the shells and the insects. Hunter himself wrote only a catalogue of his medical preparations. In 1813, John Laskey, an English antiquarian, natural historian and soldier stationed in Scotland wrote *A General Account of the Hunterian Museum, Glasgow*, which was published by John Smith & Sons. Though not a *catalogue raisonné*, this is a singularly important work in understanding the contents of Hunter's museum not long after his death. Room by room, and paying considerable attention to the natural history material, Laskey listed specimens and featured items that particularly attracted his attention or interested him - he was a conchologist so the shells get rather more coverage than other items. The brevity of some entries is frustrating to the modern reader. For example, he writes of "an immense quantity of reptiles…", or, concerning the unfortunate herbarium, "…many thousands of plants all uniformly spread on paper and in good order…"[22]. One must ask: what were they and what happened to them?

King George III created the Regius chair of Natural History at the University of Glasgow[23] with the intention of providing a curator for Hunter's collection. Hunter moved in Royal circles as he was obstetrician to Queen Charlotte; in addition, the king himself was a keen collector. Muirhead Lockhart, the first appointee, was the University Librarian who was tasked with organising the removal of Hunter's collection to Glasgow. Along with the collection, Hunter had left funds to build a home for them and architect William Stark's (1770–1813) fine "Temple to the Muses" was erected adjacent to the Old College buildings at the former site of the University at High Street in Glasgow (Fig. 1).

Fig. 1. A view of the Hunterian Museum, library and common hall, Old College 1828. Steel engraving by Joseph Swan, printed in black and hand-coloured. GLAHA:17688, ©The Hunterian, University of Glasgow.

The new museum was opened in 1807 and initially attracted considerable attention and admiration. Coutts (1909) and Keppie (2007) describe in some detail the challenges of running the museum in the middle–late 19th century, enduring issues such as external and internal politics, lack of funding, declining building fabric and maintenance, and overcrowding, combined with inadequate staffing and management. The four individuals who held the Regius chair of Natural History throughout that century all had other duties in addition to their museum responsibilities, the latter fulfilled partly according to personal academic interest - for example, in natural history, Henry Darwin Rogers (1808–1866) and Professor John Young (1835-1902) were more concerned with geology. Confusingly, overlapping with Regius Professor John Young, another John Young (1823-1900), a man of more humble origins, was appointed under-keeper in 1859. He was a hard-working, talented curator and eventually was awarded an LLD by the University in 1893 in recognition of his services. Clark (2008) provides short biographical accounts of both men. Mr John Young devoted himself to the museum collections, especially geology, but also curated the zoology collections. Examples of his work, particularly his distinctive labels are found in the zoology collections today on diverse specimens such as bones, mammal skins, shells, echinoderms and microscope slides.

For some decades, the University had been contemplating a move from the crowded, ageing, increasingly dilapidated buildings and the polluted town centre to the greener spaces of the west end. Land at Gilmorehill was purchased, the site in the town was sold to a railway company, and the leading English architect George Gilbert Scott (1811-1878) was appointed. By 1866, preparatory works had started on the grand neo-Gothic building that today bears Scott's name (Haynes, 2015). The Hunterian was allocated impressive halls along the north-east front of the building. The collections were packed up and moved in early 1870 (Keppie, 2007). Little information is available specifically on the move of the zoology material. However, there is a charming watercolour by Jemima Blackburn[24] that depicts a number of the taxidermied animals including a polar bear, tiger and giraffe and some mounted skeletons loaded onto horse-drawn flatbed carts, ready for hauling up to the new premises. The operation was overseen by a man in a top hat, whom Keppie thinks is likely to be Mr John Young. Natural History occupied most of the main gallery and it took several years for all the collections to be installed and become accessible.

Some photographs from the 1890s show serried ranks of stuffed mammals and skeletons lined up on the museum floor, with glass showcases housing smaller specimens, and antlers mounted on the walls (Fig. 2).

In 1888, the University of Glasgow received much of the Zoology content (Reilly & Sutcliffe, 2014) of the recently defunct Andersonian Museum, part of Anderson's College, a rival institution set up in the early

Fig. 2. View of main gallery of the Hunterian Museum in the Gilbert Scott Building from the 1890s, showing many zoological specimens. (Photo: T. & R. Annan & Sons, Glasgow)

19th century by John Anderson (1726-1796), former professor at Glasgow. Anderson's College eventually became the University of Strathclyde. Though no list of what was transferred appears to have been made, it was an important and useful addition to the collections, and Mr John Young diligently labelled the specimens, providing modern curators with the only means to provenance this accession. Mr John Young LLD died in 1900 after a period of illness. Professor John Young died not long after, in 1902, having demitted office some time before due to ill health.

THE 20th CENTURY: JOHN GRAHAM KERR AND THE ZOOLOGY MUSEUM

Into this scenario came Edinburgh-born John Graham Kerr, a young energetic Cambridge-trained zoologist and, amongst his many interests, a museum enthusiast. He was appointed to the Regius chair of Natural History in 1902: the chair was split into Zoology and Geology in 1903 and his title changed to Regius Professor of Zoology, which included, after some further administrative changes, the *ex officio* role of Honorary Keeper of the Zoology Collections only. He was a true believer in the use of museums for teaching and research - his personal research on embryology, development and evolution was carried out on lungfish and related material collected in the field by him and his associates, and preserved in the museum.

The Department of Natural History was accommodated in rooms on the ground floor (and basement) of north-east front of the Gilbert Scott building. The Hunterian Museum, housing the zoology collections, was conveniently situated on the floor above. Clearly there was not what might be termed today a hand-over process, nor does it appear there was much in the way of staff in the Department of Natural History. Graham Kerr leapt into action on a number of fronts: on a pre-visit to Glasgow before he formally took up his Regius post, he was less than impressed with the conditions he found in his new Department, recording in his memoir:

"There was, of course, no zoological laboratory. The

eastern half of the lower hall of the Hunterian Museum - known in later years as the Hunter Hall - had been used for what little practical work had been done, but it had no scientific equipment. Its floor was littered with geological debris: its entry was by wooden steps through one of the windows." (see *Gallery of Memories*, this volume, p. 25).

He also spotted a derelict cabinet piled up in the Quadrangle apparently for disposal – on closer inspection he found pinned and labelled insects in eight drawers, subsequently established to be part of William Hunter's prestigious insect collection. He issued instructions for their rescue and safe keeping. He had to start teaching the large undergraduate classes of medical students straight away (see *Gallery of Memories*, this volume, p. 25) and had spent the month before he started on the Isle of Arran writing his lectures. He used museum specimens in his teaching but soon declared there had to be a proper teaching museum:

"While the main teaching of the courses in Zoology had to be carried out in lecture room and laboratory, a necessary supplement was a museum for the display of specimens of importance, other than those studied in the laboratory. A teaching museum had to be created." (see *Gallery of Memories*, this volume, p. 26).

He acknowledged it would take "much money and much skilled labour", both in short supply, but said that creating a teaching museum was "the most fascinating part of my work in Glasgow". (see *Gallery of Memories*, this volume, p. 26).

One of his first tasks, in 1904, unsurprisingly given the incomplete record keeping he inherited, was to create a new accession register. He started off listing the many professional preparations acquired for teaching, which he purchased from the leading biological supply houses of the time. Then he listed the existing collections already in the Hunterian or at least those that had survived his weeding out of decayed specimens.[25] (see *Gallery of Memories*, this volume, p. 26). Kerr (1906) published a paper where he listed new accessions – a humpback whale foetus presented by the Governor of Newfoundland; specimens of the copepod *Penella*, parasitic on whales; hair balls from the uterus of a fur seal; a specimen of the hemichordate *Cephalodiscus nigrescens* collected on the Discovery voyage and described in 1905 by Ray Lankester; the horseshoe worm *Phoronis australis*; leptocephalus larvae of eels; tsetse flies *Glossina palpalis*, recently identified as an intermediate host of trypanosomiasis. This was indeed an eclectic selection, taxonomically and geographically, including new species and discoveries, from a variety of distinguished donors and scientists. Later, Kerr (1910) published the proceedings of a talk to and a visit by the Glasgow Naturalists to the Museum. In the first half of the paper, he opined on the function and presentation of a University museum of Zoology and in the second half he turned to the type specimens from Hunter's collection he had located in the collection - an incomplete list of the Fabrician insect types, 20 specimens of Ellis and Solander coral[26] and the Ellis crinoid[27]. He acknowledged that much work needed to be done with this material and wrote that the function of his paper was to once again draw expert attention to it.

JGK was a man of strong views clearly expressed and his opinions on museums were no exception. He was opposed to overcrowded displays with many specimens jammed in with no labelling or focus - one good specimen accompanied by a concise informative label would serve its purposes much better. Bad quality, decayed specimens giving a poor impression should be disposed of and, if feasible, replaced with good examples of their species. University museums were for teaching, and perhaps showing a wider range of taxa of zoological importance, rather than more flamboyant specimens (often now called "charismatic megafauna") - that job was better left to the magnificent municipal museum at Kelvingrove. Labels should be letter press in gold leaf on matt black paper. Lighting should be adequate but not so bright as to fade specimens; daylight should be excluded or controlled. Showcases should be purpose-built with specimens easily viewable, and designed to keep out dust and pests. A modern curator could agree with much of this.

As ever in museums, money was an issue. In 1904, JGK estimated £3,665 was needed to get the Zoology Museum in order. He was able to extract a promise of a grant of £1,000 (of the £3,665 needed) on a matched funding basis between the University and the Bellahouston Trustees to develop the museum. The money appears to have materialised in 1907 and JGK had to eke it out over five years, reporting it all spent in the 1911-1912 Museum annual report. Though £1,000 in 1907 is the equivalent of the not inconsiderable sum of approximately £100,220 in 2024, the zoology collections had almost a century of neglect to remediate. However, further sums were not forthcoming and JGK chided the University authorities in the 1913 annual report for their failures and prompting the release of another tranche of funding for the Hunterian, including £500 specifically for Zoology.

With the limited resources available, JGK did his utmost to better utilise the existing arrangements with the Hunterian collections – he had electric lighting installed in 1909, enabling work during the winter, and in the period 1907–1912 arranged for the purchase of cases to improve display of some of the specimens. However, his master plan from the time he arrived was to have a brand-new department built for Zoology, the key features of which would be a capacious lecture theatre, a large teaching laboratory and a fine museum hall (Haynes, 2013). By 1914, JGK had agreement from the University authorities that a new building would be commissioned but the outbreak of World War 1 halted all development. The project was picked up again after the war and the leading Glasgow architect John James Burnet (1857-1938) was engaged to design the new building. By 1921 plans were agreed and work began. Classical in style and said to be inspired by the Roman Baths of Caracalla, the beautifully proportioned

museum gallery featured a central sunken well, surrounded by a colonnade on three sides, supporting a cleverly shaded glass roof. There were collection storage rooms in the basement and a curator's office along the corridor leading into the museum.

The building was open by October 1923 when JGK delivered his first lecture in the new lecture theatre, and in December, the grand Rectorial dinner that featured a famous controversial speech by the Rector, Lord Birkenhead[28] was held in the empty Zoology Museum. Transferring collections safely is a time-consuming and laborious process and the gallery exhibits were not fully installed till at least 1924. In the annual report for 1922-23 JGK notes that whilst the museum's primary function is the teaching of university students, it can also serve to instruct the public and to that end the University Court have agreed that it may be opened from 3-5 p.m. on Saturday afternoons from Winter Session 1925-1926. (Fig. 3.)

Fig. 3. The Zoology Museum in the 1930s. (Photo: T. & R. Annan & Sons, Glasgow)

Members of the Zoology staff assisted JGK in the development and curation of the Museum. Lecturer in Oceanography James Chumley[29] supervised the transfer of the collections to the new building, catalogued collections, and curated the marine invertebrate material; Robert Staig curated the growing entomology collections, prepared teaching displays, and also produced two volumes on some of the Fabrician type Coleoptera in the Hunter collection (Staig, 1931, 1940). Wilfred Agar[30] and George Carter[31] both followed in JGK's footsteps, undertaking expeditions to the Grand Chaco - Agar in 1908, Carter in 1928, and deposited fish, mammal and other specimens in the museum collection. Charles Parsons[32] represented the Zoology Museum at The Museums Association, a professional organisation for U.K. museums.

For the ten years preceding his retirement from the University and having achieved his aim of a new building to house the Department and a beautiful new teaching museum, JGK in his annual reports wrote mostly of achievements such as Staig's publications, the acquisition of important material, the routine running and maintenance of the museum and acknowledgements to colleagues for their contributions.

AFTER GRAHAM KERR

Graham Kerr demitted office in 1935, formally signing over his specimen collections, papers and books to the Museum and the University. Entomologist and parasitologist Edward Hindle (1886-1973)[33] succeeded him in the Regius Chair and led the Department through the World War 2 years. As in World War 1, the department was again depleted of staff and students called up for military service. Hindle kept the museum going, assisted by technician Mr C. Bain, running teaching and maintaining the collections. Hindle enhanced the data quality of the collection by arranging for parts of the Bishop and King entomology collections to be sent off to expert taxonomists in the British Museum Natural History (BMNH, now NHM) in London for identification and organisation – such sharing of expertise is a standard practice to this day. The museum collections were still growing: various accessions are recorded, including numerous golden hamster (*Mesocricetus auratus*) specimens. Hindle is credited with introducing the golden hamster to Europe from wild specimens caught in the Syrian desert, for use as laboratory (and subsequently pet) animals. In 1941, the Zoology building and the museum sustained blast damage from a bomb dropped on nearby Kelvin Way. The glass canopy museum roof was damaged and leaking but other than glass shards all over the floor, the museum displays were largely unaffected. In 1938-39, Hindle reports on the installation of the first live animal displays in the museum - several tanks of tropical fish; live displays were resumed in later years. In his time in Glasgow, Hindle was instrumental in the foundation of Glasgow Zoo and he departed in 1943 to follow his zoo interests and take up a post as director of the Zoological Society of London. In 1944 Sir Charles Maurice Yonge[34], an eminent marine biologist, was appointed to the Regius Chair and so became honorary keeper of the museum.

The Department and Museum were very much as JGK had left them. In his first annual report for year 1944-45 to the Court, Yonge commented the museum had been well maintained by the museum technician (Mr Bain) but was in a poor state of décor and needed painted, hardly surprising after blast damage in 1941. Anthony Downes returned from war service and resumed working through the Bishop Coleoptera collections, again dispatching them to experts for identification. Other parts of the collection also received attention – in 1949, Yonge mentions research queries or visits from eminent scientists Wilfred Le Gros Clark, Solly Zuckerman and Robert Broom, all anatomists/palaeontologists working on primate biology and evolution. There are few accessions recorded – generally the case in all of his annual reports to the Court over the period of his keepership (1944–1964). The important exception to this, however, is extensive field collecting in entomology and of some other arthropods by Drs Downes, Crowson (and Mrs Elizabeth Crowson

as a volunteer collecting and curating a collection of spiders) and the agricultural zoologists Drs Alex Hill and Ron Dobson.

By 1947, the post war increase in student numbers necessitated the southern end of the museum being converted to laboratory space, with the installation of benches and sinks to accommodate practicals for 500 first year arts and science students. By 1950 another area was cordoned off for advanced students (Fig. 4).

Fig. 4. The Zoology Museum around 1950 showing its conversion to a crowded teaching space. (Photo: Department of Zoology Archives/University of Glasgow)

Of these necessities (and Yonge had wryly commented that the Zoology building was designed "as though the needs of 1923 were those of eternity") the museum was cramped, its elegant Graham Kerr layout compromised and public access was not available in term time. However, collection work continued, particularly on entomology with Dr Downes reporting much research activity.

In 1948, a start was made on the first of the post-war modifications to the building, breaking through the thick stonework of part of the north wall that formed one side of the museum to create access for an extension to house the expansion of teaching and research in Agricultural Zoology. This building work occasioned much disruption and ingress of dirt to the museum but also resulted in the opening up of previously unusable areas of the basement and some of these were assigned as museum storage space, albeit of deeply inadequate standard. Roy Crowson had joined the staff in 1949 specifically to work with the museum collections *per se*, thereby, to Yonge's relief, freeing up other staff to deal with teaching the 500 students passing through the Department. In 1950 Charles Parsons, who had been an able depute to both Hindle and Yonge, died suddenly and Yonge acknowledged his care of and pride in the museum even though he had no official or honorary responsibilities there - he had been in effect the assistant curator.

The museum was finally painted, presumably recovering from its wartime state and the recent building work, and Yonge thought that JGK's characteristic black and gold labels were dark and outdated and needed replaced. Yonge mentioned preserved and labelled dissections by students, then a requirement of the Honours course, introduced by him but supervised by Dr Harry F. Steedman, a research technologist and internationally renowned expert in animal preservation who came to Glasgow with Yonge from Bristol University. Some of the dissections remain in the collection today and are of excellent quality, testimony to Steedman's influence (Fig. 5).

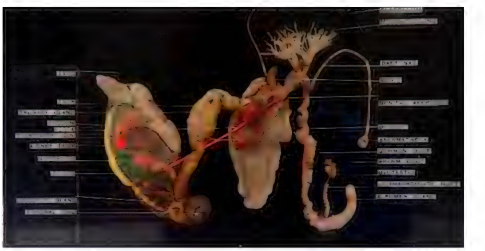

Fig. 5. Dissection of the garden snail, *Helix pomatia*, to show internal anatomy, by Honours student Miss N.M. Davidson, 1948. (Photo: Department of Zoology Archives/University of Glasgow)

In the mid-1950s, Yonge was exasperated by the lack of museum staff and overcrowding of teaching in the museum leading to its deterioration. His suggestion that the large teaching laboratory could be horizontally divided to create another floor was finally acted upon in 1957 creating much needed teaching and research space. The museum needed restoration after the student classes moved out and in 1959 with the help of a temporary technical assistant, Mrs MacAulay, the museum refurbishment was completed, to Yonge's satisfaction. JGK having died in 1957, memorial events took place in the department in 1959, including the unveiling of his portrait by Arthur Wells that presently hangs on the first-floor landing.

By 1961, public access was restored and a permanent part-time museum assistant Ellison Macartney was appointed. Most research activity was still focused on the entomology collections, though Dr W.M.A. De Smet of Louvain University in Belgium, who worked on the archaic fish *Polypterus,* came to study the specimens collected by J.S. Budgett[35] (which had been given to JGK) in the early 20th century. De Smet (1980) cited the Glasgow specimens.

Yonge encouraged some exploration of the large but neglected shell collections in the museum. Dr Peter Dance of the BMNH and Mr Fred Woodward (1939-2020) of Birmingham Museum (later depute Keeper of Natural History at Glasgow Museums), both experts in historic shell collections, came to examine the University material. In 1962, there was much excitement at the discovery of a specimen of a rare species, *Conus gloria-maris*, the glory of the sea cone shell (Dance and

Woodward, 1963). Indicated by its rarity (at that time only a handful of specimens were known in the world) and some historic documentation, this shell could only have originated in William Hunter's collection. The more important discovery here was the evidence gathered by Dance and Woodward that at least some of William Hunter's notable shell collection, previously feared lost or destroyed (Wilkins, 1955) was in fact still extant, if admixed with other later collections and lacking original labels.

Yonge retired in 1964 and in his final report he recommended that, with the freeing of space due to the removal of the first-year classes, the museum develop an area where students could sit, study and discuss aspects of Zoology. This came to pass at a later date and the museum has for many years been a vibrant and popular study space for students to work, learn and relax.

Professor David Newth[36], a developmental biologist, took up the Regius chair in 1964 and in the second half of the 1960s there were drastic internal modifications to the museum. Around 1966, the museum colonnade on the north side and north-west corner was walled off to form a museum store, an entomology room, a histology laboratory and a lecture theatre; the ever-leaking glass roof was removed, the museum roof covered over and a new laboratory built on top of it, this necessitating new arrangements for ventilation, heating and lighting in the museum. On the positive side, for entomology at least, the facilities were improved with equipment, library and some collections co-located in the new room and with limited space for visiting researchers to work. Dr Crowson continued to publish regularly and supervised two PhD theses on the collections during this period.

In the 1966-67 annual report Newth confirmed that the museum continued to have an important role in undergraduate teaching and also expressed a desire that the permanent displays be supplemented with occasional temporary displays to refresh interest in the collections. By 1970, the museum was preparing for the infill of the remaining colonnade (along the south wall and south-west corner) to form laboratory and office rooms for a new electrophysiology research unit. Yet again the museum was disrupted and more specimens were removed to storage in the profoundly unsuitable basement below the museum. In summer 1971, Newth wrote that "the past session has been a difficult one for the Zoology Museum" and reported problems particularly for the fragile insect collections with vibrations from the new ventilation system.

In the mid-1970s, two significant events happened that dramatically improved the prospects for the museum. In 1975, Dr David C. Houston[37], ornithologist and behavioural ecologist, joined the Zoology staff. Very keen on museums and collections, in the Graham Kerr manner, he volunteered, and David Newth gratefully accepted his offer, to take over the role of honorary assistant curator. By this stage, because of the long period of disruption and lack of resources over the preceding decade or more, there was a very real risk that the Zoology Museum would be lost to the University, and the remaining collections donated to the National Museum in Edinburgh – a fate that had earlier befallen most of the Edinburgh University Zoology Museum. It was decided that the future of the museum could only be protected if it was made to play a far more active role in the work of the Zoology Department. Zoology is such a wide-ranging subject that it was becoming difficult to find time in the busy teaching curriculum for classical animal kingdom coverage, and this was clearly a role the museum could fill. A self-teach course on the animal kingdom was developed, which after various revisions is still part of the teaching curriculum today. It covers the major phyla and is based on the excellent reference collections in the museum stores.

Abandoning the previous small-scale efforts on display refreshment, it was decided to embark on a major refurbishment of the permanent displays. David Houston developed and led on this critically important programme. Though permanent museum staffing at this point was better than in the past – Ellison Macartney was still in post as a part-time museum assistant and Mary Stewart had been appointed in 1976 as museum technician - such an undertaking was made possible only via dedicated additional staffing. This came in the form of short-term posts for graduates, funded through the Job Creation Programme (JCP) of the Manpower Services Commission[38]. Apart from covering staffing costs, the JCP also provided much-needed funds for materials and equipment, for example enabling the purchase of new showcases, always an expensive item. However, such funds only stretched so far and David Houston (pers.com.) gratefully recalls help from the University Estates and Buildings Department who supplied piles of bricks to build displays plinths! The display redevelopment required "re-discovery" and consideration of the specimens previously consigned to the dreadful conditions in the basement. Much of the taxidermy turned out to be still in excellent condition largely due to three factors – it was of the finest quality in the first place; it had been protected from pest damage by the application of arsenical soap to the inner surface of the skins - a standard preservation practice in taxidermy for many years; and, fortunately, it had been packed in robust purpose-designed storage crates. There were surprises exploring the many long-forgotten storage crates in the basement and a number of important specimens were re-found – including one of the very few intact eggs of the extinct giant elephant bird (*Aepyornis*) of Madagascar, purchased in JGK's time from Rowland Ward. Additional professional help and advice on specimens were sought and generously given from museum colleagues such as Dr Ian Lister, formerly curator of birds and mammals at the National Museum of Scotland, and Dick Hendry[39], formerly taxidermist at Glasgow City Museum at Kelvingrove. As well as returning many specimens to the displays, the remaining material in the basement was removed to storage in the attic space, which had the significant advantages of headroom, more stable temperatures and better lighting.

Live animal displays were also re-introduced at this time

- initially some weaver birds but subsequently (until 2020) tropical fish, spiders, scorpions, insects, reptiles, frogs and mammals including, in partnership with Chester Zoo, a breeding and re-release programme for harvest mice. Over these years, a number of Zoology technical staff and numerous volunteer students gave much appreciated help with the maintenance of the live animal displays.

These developments in teaching and displays were a new start for the museum and were accompanied by the first foray into data capture, again by JCP-funded staff, to prepare the study collections for computer cataloguing. Permanent staff changes occurred at the end of the 1970s with Ellison Macartney departing in 1977, Mary Stewart in 1979 and the appointment of Maggie Reilly in 1978, initially as part-time museum technician and then, in 1980 as full-time museum assistant (later titled curator). The technician role was lost for good at this point. In 2021, Maggie Reilly retired and Mike Rutherford was appointed curator of the Zoology and Anatomy collections[40].

The second significant change of the 1970s was the appointment in 1976 of Professor Frank Willett (1925-2006), anthropologist and archaeologist, as the first director[41] of the Hunterian Museum and Art Gallery, with the aim of bringing the diverse collections back under one leadership that would assume responsibility for the staff. The existing honorary curators became *ex officio* members of the Museum Committee (a committee or sub-committee of Court)[42]. The Zoology Museum had a strong presence and working life in the Zoology Department but gradually engaged with the new administrative arrangements to mutual satisfaction, the collections benefitting from professional museum practices and a collegial environment with fellow Hunterian staff. The Hunterian in turn benefitted from the skills, knowledge and talents of the zoologists who invested their time and dedication in the Zoology Museum.

By 1986, the refurbishment of the displays was accomplished with an updating of the invertebrates display and a complete re-painting and re-lamping of the gallery. Sir David Attenborough opened the refurbished gallery on the 29th of April 1986 and ten years of work was celebrated (Fig. 6).

Many externally funded temporary staff contributed to the achievement. In parallel, the often less visible but essential regular work of the museum – collection management (conservation, maintenance and cataloguing), university teaching, outreach and research activity continued. Especially important between 1982 and 1985 was some further grant-funded work on the Hunter insect collection by Dr James Flanagan who, following on from Robert Staig, worked on the Coleoptera mostly, meticulously researching and characterising 2,700 Hunter specimens.

Not long after the completion of the new displays, in February 1988, disaster struck with a fire in the

Fig. 6. The Zoology Museum after its rebirth in 1986 also showing the spaces behind the colonnade cut off to form offices, laboratories and stores. (Photo: Department of Zoology Archives/University of Glasgow)

Physiology Laboratory, which sat on the museum roof – detailed elsewhere in this volume (see Phillips, 2024). It was a horrifying event and the laboratory was completed destroyed. Thanks to the rapid deployment of Glasgow City Fire Brigade, the fire did not spread down into the museum, where there was a real risk that the burning roof timbers would fall into the museum well and destroy the whole building. But the vast amount of water used to douse the blaze resulted in the museum suffering extensive flooding. Remarkably very few specimens were destroyed and damage was limited, the latter largely due to the helpful and understanding practice of the fire officer in charge and his crew. As soon as safe access could be established, willing staff and student volunteers were allowed into the museum to remove vulnerable specimens to a safe place. However, the fabric of the museum was ruined and décor, flooring, lighting, graphics, showcases, exhibition stands and a few taxidermy mounts needed repair or replacement (Fig. 7).

Fig. 7. The Zoology Museum after the Department fire of 1988. (Photo: Department of Zoology Archives/University of Glasgow)

This was a blow so soon after completion of a long-

awaited refurbishment. When the insurance matters were settled, funds were released to employ two external staff, John Harrison[43] and Lyn Collins, to remake the displays and provide for a modest upgrade of some of the 1970s makeshift museum stands to more professional exhibition plinths. The displays were re-launched in April 1990 by former Zoology student, Lady Marion Kerr Fraser, wife of the University Principal, Sir William Kerr Fraser. In 1994, after administrative changes in the Faculty of Science, the building was named to honour John Graham Kerr and a commemorative exhibition created.

Significant advances were made with collection management in the 1990s. In 1991, additional space at the back of the museum was made available for collection storage, which would allow the overcrowded osteology and the fluid-preserved collections to be stored separately, which is approved practice. A Pilgrim Trust grant was obtained to provide for fit-out of the new store and a project officer - Ann Nicol[44] - was appointed to carry out conservation and maintenance, catalogue and move the collections. In 1993, the Hunterian introduced its first online computer catalogue, INCA, developed by the Hunterian geology curator Dr John Faithfull, for all the collections, thereby bringing new technology to data management as specimens were gradually added to the database. Hunterian geology staff members Camilla Nicol and Jeff Liston helped with data capture and entry for vertebrate collections. In later years and as digital technologies advanced, the Hunterian adopted the KE EMu collections management system.

The end of the 1990s and the start of the new millenium brought considerable further involvement of the zoology staff in exhibition projects at the main Hunterian in the Gilbert Scott Building. "The Animal Construction Co." exhibition and education programme on animal architecture was the Hunterian's contribution to the U.K. City of Architecture and Design award conferred on Glasgow in 1999. The exhibition was co-curated by Professor Michael Hansell whose research collections were now being deposited in the museum. A handbook catalogue (Hansell *et al.*, 1999) accompanied the exhibition. Several other temporary exhibitions with zoology content followed, such as "Stubbs and the Hunters" (art show, 2004), "This Unrivalled Collection" (mixed collections, 2013) and an international travelling exhibition and catalogue to celebrate William Hunter's Tercentenary "William Hunter and the Anatomy of the Modern Museum" (Campbell *et al.*, 2018). A complete refurbishment of the permanent exhibits in the main Hunterian galleries, to celebrate the bicentenary of the Hunterian Museum in Glasgow, was opened in 2007 and included new displays on zoology. It was accompanied by an international conference and then a publication with contributions from all staff (Hancock *et al.*, 2015). Alongside this work for the wider museum, the regular work of the Zoology Museum continued apace with increased student use both internally and from other Higher Education Institutions (HEIs) in Glasgow: Glasgow School of Art, University of Strathclyde, University of the West of Scotland and various colleges brought their students either for zoology classes or for art and design drawing.

Zoology staff entomologists continued to contribute to the collections. Dr Ron Dobson, who retired in 1986, deposited his personal collections in the museum and continued to work on curating British Coleoptera. In 1999, Dr Roy Crowson, still working on the collections and productive to the end of his long life, passed away. In 2006, a Leverhulme award provided funding for further work on William Hunter's collection. Dr Starr Douglas, a cultural geographer and historian, and Georgie Broadsmith Brown, an entomologist, were employed in the project titled "An Analysis of William Hunter's Insect Cabinet in a Scientific and Cultural Context" from which several research papers were published (e.g. Douglas *et al.*, 2007; Hancock *et al.*, 2008). An unexpected entomological highlight in 2009 was the loan of a beetle, *Lissopterus quadrinotatus*, collected by Charles Darwin, to the Palazzo delle Esposizioni in Rome as part of their Darwin 1809-2009 exhibition. It is the only Darwin specimen in the zoology collections and had been discovered a few years earlier in the Bishop Collection during routine curation. Also in 2009, the Zoology Museum welcomed Cathy Fielder[45], the first of two recipients of a Natural Talent Traineeship run by The Conservation Volunteers. This scheme aimed to train young taxonomists in specific taxa to mitigate the loss or lack of such skills (Horsley & McFarlane, 2017). Cathy Fielder specialised in Hymenoptera and the second appointee, Moya Burns[46] worked on saproxylic beetles.

From the mid-1990s, national benchmarking and standards programmes, such as National Audit, Accreditation[47], Significance and Recognition[48] were introduced for British museums. It is critically important to participate in these schemes not least for eligibility for external funding. Complex data research and collation by all staff were required for the entire museum to inform the submissions. The information gained in these processes greatly added to the internal understanding of the collections, enhanced profile and presence, and resulted in The Hunterian achieving and maintaining Accreditation, being recognised as a museum of National Significance (the first of these awards given) and gaining access to additional grant funding.

In 2008, significant change was yet again under consideration for The Hunterian. A University committee led by the Secretary of Court was tasked with exploring the future of The Hunterian with a particular focus on collections access and storage. The collections had grown in all disciplines, and storage facilities were full or overcrowded, of poor quality and scattered around the campus and beyond. The proposal emerging from the committee was that a new storage and access facility be developed at the nearby Kelvin Hall, in collaboration with Glasgow Life and National Libraries of Scotland (NLS). Glasgow Life own the venue and had collections of their own to re-store and the Edinburgh-based NLS were looking west for a home for their

moving image archive and digital collections.

University funding along with Heritage Lottery Funding (HLF) and other grants provided for the development of a portion of the westernmost third of the building as The Hunterian Collections Study Centre. A large central store with controlled environmental conditions and kitted out with modern mobile shelving houses the collections. Study rooms, offices, laboratories, student spaces and a lecture theatre are also provided. Following the project development years, the zoology collections were inventoried, packed, moved over and installed in this new facility between 2014 and 2016. The Kelvin Hall Centre is a step-change in the quality of storage provision and management for the zoology collections (Fig. 8).

Fig. 8. Zoology collection storage in the Hunterian at Kelvin Hall.

The Scottish Government's First Minister Nicola Sturgeon came to open formally The Hunterian at the Kelvin Hall in November 2016.

At present, some of the more regularly used teaching collections remain in the Graham Kerr Building alongside the Zoology displays, the latter much as they were following the 1990 refurbishment, but for the addition of the eye-catching insect display in 1999 (Fig. 9).

Extensive renovation of fabric and display content is required once again, though the recent introduction of intervention labels, e.g. small labels applied to the exterior of the display cases, screen-based communications or the use of mobile phone apps such as Bloomberg Connects, allows for some updated

Fig. 9. The Zoology Museum around 2000, showing the post-fire restoration and the new "Insects" display.

scientific information to be presented. University teaching remains a constant for the Zoology Museum – it is one of its most important activities as instituted by JGK. The permanent displays are intended to function as a 3-D snapshot of the animal kingdom, giving an insight into biodiversity and evolution. There are over 1.5 million recognised animal species and over 600,000 animal specimens in the zoology collections. As only a tiny fraction of this diversity can ever be on show in the museum, in JGK's tradition, key species or the best specimens are selected for display. Students can use these displays at any time either informally or as part of taught classes. Special demonstration classes using material brought out from the store are laid out in teaching laboratories or the museum itself and have covered topics from comparative dentition and parasitology to amphibian reproductive adaptations, food security and coral diversity (Fig. 10).

Fig. 10. Zoology junior Honours students, mid-1990s, in a demonstration class in the Zoology Museum.

In recent years, and with a rise in interdisciplinary studies, the zoology collections have also been of use in teaching and research beyond zoology in subject areas such as environmental art, literature, human geography, museum studies, technical art history and history of science. Honours, Masters and PhD research projects are routinely offered or supported.

Public access to the Zoology Museum varied over time dictated by departmental needs, but from the late 1970s

the museum has been open to the general public for drop-in visits on weekdays from 9 a.m. to 5 p.m. However, universities have been undertaking more active engagement with the wider community and their various audiences for many decades now and the Zoology Museum has been involved in numerous outreach programmes. One of the most significant running from the late 1970s to the mid-1990s was the Primary School Project developed by Zoology staff, with the support of the Zoology Museum and in collaboration with Strathclyde Regional Council Education Department, the education authority at that time. Volunteer undergraduate students (mostly first and second years) were allocated to primary schools across the region to teach biology to children. The students were supported with information, lesson plans on set topics, advice and specimen kits from the museum (themes such as Flight, Snakes, Birds, Animal Skeletons, and Insects were offered). Several visits could be made to the school by the student team and the last session of the programme was to bring the children into the museum for a visit and conduct a special activity there. Live animals, carefully selected and usually from the museum displays, supplemented the excitement. The project worked well for the children, teachers and the education authority; the students gained confidence and perhaps having attracted those who were considering a teaching career helped guide their choices, and the museum served a wider community. Assorted education programmes, often dependant on soft funding, for children from toddlers to S6 school students, came and went over time. The Zoology Museum also developed activities for all ages to enhance special exhibitions and programmes run by the main Hunterian Museum. Zoology staff and collections support student recruitment by hosting Campus Days and contributing to the University "Widening Participation" service including the present "Into University" programme. In recent years, the Zoology Museum has been participating in city-wide programmes such as the Glasgow Science Festival and Doors Open Days.

CONCLUDING REMARKS

The zoology collections at the Kelvin Hall Centre are now housed in the best quality storage they have ever had. Access to and cataloguing of the collections is supported by the Hunterian specialist Collections Management team. The Zoology Museum - at the physical heart of the Graham Kerr Building - is a much loved and well-used space by students, staff and visitors. In addition, use of museum staff expertise and the collections in teaching is increasing, productive and mutually supportive relationships with zoology staff are thriving, numbers of public visitors have increased, and research use of the collections is also flourishing and diversifying in multidisciplinary ways. Ambitions for the future include the modernisation of the teaching displays in the Zoology Museum and expanded open access to specimen data through upload to the online aggregator GBIF (the Global Biodiversity Information Facility)[49].

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APPENDIX

Notes

Sources cited in these notes are included in REFERENCES (above).

1. Data standards for accession records, catalogues, labels and other forms of information (whether paper or digital) relating to museum objects, are a large sub-genre of museum practice. Depending on circumstances records are not always made consistently by museums. Even if records are kept, they can go missing or be destroyed. Aside from legal considerations, lack or loss of specimen data can seriously diminish a specimen's scientific utility. For biological material, key information on place and date of capture are especially important as well as the name of the person who gathered the material. Habitat data are also important.
2. Professor August Bernhard Brauer (1863–1917); German zoologist, mainly known as an ichthyologist, was Director of the Berlin Natural History Museum. In 1894–95, he went on expedition to the Seychelles and subsequently carried out pioneering morphological and embryological studies on Gymnophiona (caecilians), the legless amphibians.
3. The German Deep Sea Expedition (*Deutsche Tiefsee-Expedition*), also named after the vessel SS *Valdivia*, was a government-funded expedition tasked with exploring the deep ocean below 500 fathoms. It was led by marine biologist Professor Carl Chun and operated from 1898–1899.
4. Thomas Wayland Vaughan (1870–1952) was an oceanographer and geologist who worked for the United States Geological Survey, the Smithsonian Museum and eventually became director of the Scripps Institute.
5. Scleractinian corals including type and figured specimens described by leading 18th century naturalists John Ellis (1714–1776) and Daniel Solander (1733–1782) (Ellis & Solander, 1786). Some of the specimens were collected on the Endeavour voyage of Captain James Cook.
6. Rowland Ward of London was the most famous firm of British taxidermists over the Victorian period and into the 20th century. See Morris (2003) for a full account of the Wards' life and business.
7. In the U.K., second only to Rowland Ward, Gerrards of London, in business from the mid-19th to the 20th century prepared and sold taxidermy, skulls and skeletons to private individuals, museums, universities and other educational establishments. See Morris (2004) for a full account of the Gerrards' life and business.
8. Václav Frič (?1839–1916) was a Czech naturalist and natural history dealer with a specimen supply business based in Prague. Amongst much else, the company produced fine, wet-preserved preparations such as the beautiful delicate cartilaginous skeletons of sharks or the life cycles of insects and amphibians. See Reiling & Spunarová (2005).
9. The marine station in the Bay of Naples was privately founded in 1872 by the German zoologist Anton Dohrn (1840–1909) and was the first zoological research station in the world. It offered bench space and excellent facilities to visiting scientists, and there was a public aquarium. Fees gained from both plus the sale of preserved specimens and publications funded the running of the station. Latterly named in his honour, the Stazione Zoologica Anton Dohrn was taken over as a national institution by the Italian Government in 1982 and continues its research into many aspects of zoology.
10. Henry Augustus Ward (1834–1906); a naturalist, geologist and collector who worked with Louis Agassiz. He founded Ward's Natural Science in Rochester, New York, which prepared and sold specimens to universities and museums around the world.
11. Charles Kirk (1872–1922) was trained in taxidermy at Rowland Ward's in London. He returned to Scotland and set up shop in Sauchiehall Street, Glasgow. It was the biggest and best-known taxidermy studio in Scotland. Kirk was a skilled preparator, artist, photographer and field naturalist.
12. For further info see Reilly & Russell (2008).
13. The Catalogue of Life website provides statistics: of the 1,510,453 formally described species of the kingdom Animalia recognised in 2024, 973,103 are insects – approximately 75% of all known animal species. https://www.catalogueoflife.org/data/taxon/N Accessed 5th February 2024.
14. Robert Arnot Staig. See *Gallery of Memories*, note 87.
15. Frederik Vincent Theobald (1868-1930); English entomologist who specialised in the taxonomy of mosquitoes just after their role in the transmission of malaria was discovered, writing a foundational five-volume work, *A Monograph of the Culicidae or Mosquitoes* between 1901 and 1910. Worked at the British Museum.
16. Alexander Cuthbertson (1901-1942) was a Scottish dipterist who specialised in crane-flies. He worked in Zimbabwe as an economic entomologist.
17. Roy Albert Crowson. See Downie (2024), note 22.
18. Alexander R. Hill (1909–2006) was appointed to a lectureship in 1949 (retired 1984) and was tasked with developing and delivering degree courses in the newly established Agricultural Zoology specialism of the Department of Zoology. He was an entomologist specialising in insect-borne (particularly aphid) diseases of plants. He also worked on the hemipteran *Anthocoris* and carried out insect survey work on the Scottish SSSI The Black Wood of Rannoch. Specimens from all of this work are deposited in the Hunterian collections.
19. Ronald M. Dobson (1929–2019) was appointed lecturer in Agricultural Zoology in 1959 (retired 1995). He was an entomologist specialising in beetle and fly pests of crops and stored products. Later in his career he studied mites. He also published on the natural history of the Scottish Islands. He deposited much of his teaching, field and research collections in the zoology museum and volunteered as an honorary curator.
20. John Anthony Downes. See Downie (2024), note 14.

21. William Cullen (1710-1790) - physician, chemist and teacher - was a towering figure in the Scottish Enlightenment and the development of medicine and science in Scotland and beyond. He held academic posts at Glasgow and Edinburgh Universities and was president of the Royal Colleges in both cities. He was doctor to the king, various aristocrats and leading public figures of the day, and trained many doctors who in turn were of huge importance in the history of medicine.
22. See Laskey (1813; reptiles p. 22; herbarium p. 30).
23. Appointments to this chair since its inception:
    Regius Chair of Natural History:
    Lockhart Muirhead MA LLD (1807)
    William Couper MA MD (1829)
    Henry Darwin Rogers MA LLD (1857)
    John Young MD (1866)
    Regius Chair of Zoology:
    Sir John Graham Kerr MA LLD FRS FRSE (1902)
    Edward Hindle MA PhD DSc FRS (1935)
    Sir Charles Maurice Yonge CBE PhD DSc FRS (1944)
    David Richmond Newth BSc PhD FRSE (1965)
    Keith Vickerman PhD DSc FRSE FRS (1984)
    Chair vacant 1998–2012
    Patricia Monaghan BSc PhD FRSE FRS (2013)
24. Jemima Wedderburn Blackburn (1823–1909) was from a notable Scottish family and had married Hugh Blackburn, the Professor of Mathematics at the University. She was a talented and prolific artist who often painted natural subjects especially birds. Her 1870 watercolour "Moving the Contents of the Old College Museum" remains (in 2024) in the ownership of the Blackburn family. With their kind permission it is reproduced as the cover of Keppie (2007) and as an illustration in Hancock *et al.* (2015).
25. Kerr and his successor Yonge, in their annual museum reports to Court, refer to disposal of decayed specimens but no lists seem to have been kept, further complicating modern curatorial attempts to track specimen provenance.
26. See Campbell *et al.* (2018; pp. 376-380).
27. See Campbell *et al.* (2018; p.381).
28. Frederick Edwin Smith, 1st Earl of Birkenhead (1872-1930); controversial British Conservative and Unionist politician and lawyer. The speech was entitled "Idealism in International Politics".
29. James Chumley (1886–1948) joined the Department around 1916 (?) initially as a teaching fellow then later becoming lecturer in oceanography. As well as his teaching duties at Glasgow, Chumley worked on faunistic records for the Clyde Sea Area publication in 1918 of the valuable *Fauna of the Clyde Sea Area*.
30. Wilfred Eade Agar (1882-1951) joined the Department in Glasgow in 1904 as a demonstrator. As well as teaching, at Graham Kerr's suggestion he took up a study of the development of the cranial anatomy of lungfish utilising material collected by Kerr on his expeditions to the Paraguayan Chaco. In 1914, the culmination of several years work, he published important papers describing cellular mechanisms in spermatogenesis. In 1919, he left Scotland to take up the Chair of Zoology at the University of Melbourne.
31. George Stuart Carter (1893–1969) was appointed to a lectureship in 1923 and undertook general teaching duties. He worked at the Millport Marine Station and produced a series of papers on reproduction in echinoderms. He was a keen evolutionist, deeply interested in the adaptive pressures on animals living in tropical swamps and published several papers on this subject. He left Glasgow in 1930 to take up a post at Cambridge University.
32. Charles Wynford Parsons (1901–1950), a vertebrate zoologist from Cambridge University, was appointed to an assistant lectureship in 1926. His research interests were in the morphology of fish, and bird embryology. Parsons was a popular teacher in charge of the medical classes and a capable administrator, involved in running the Department especially in the World War 2 years.
33. Edward Hindle (1886-1973) was an English zoologist educated in Bradford, London, Berkeley California and Cambridge. He worked in the field of medical entomology and specifically the arthropod transmission of disease. His principal researches were on leishmaniasis, yellow fever and spirochaetosis.
34. Charles Maurice Yonge (1889–1986) was one of the most influential marine biologists of the 20th century. Educated at Oxford, Edinburgh and Cambridge, initially he worked on marine bivalves particularly oysters. He led the famous 1928–29 Great Barrier Reef (GBR) Expedition. In 1933 he was appointed Professor of Zoology at the University of Bristol and thence to the Regius Chair at Glasgow. He produced many scientific publications and also wrote for the public audience: his 1949 book *The Sea Shore* is a classic and has remained in print. A side note to the GBR expedition - one of the expedition team was Professor Thomas A. Stephenson, marine biologist and talented artist who painted animals and landscapes from the expedition. A gallery in London mounted an exhibition of Stephenson paintings, half a dozen of which Yonge purchased for the Zoology Department in 1963. The paintings were hung around the Department for many years and are now accessioned into the art collections at the Hunterian.
35. John Samuel Budgett (1872-1904); Trinity College Cambridge zoology graduate and friend of John Graham Kerr. Accompanied Kerr on the second Gran Chaco expedition in 1896 where he worked on amphibians. Subsequently worked on the African bichir fish *Polypterus* to determine its evolutionary affinities. Contracted malaria whilst on field work and died young.

36. David Richmond Newth. See Downie (2024), note 39.
37. David C. Houston joined the lecturing staff in Zoology in 1975 and retired 2005. His research interests included feeding and digestion in birds and mammals, the ecology and conservation of vultures, and physiological aspects of ecology. Has wide interests in zoos and museums.
38. The Manpower Services Commission (MSC) was a non-departmental public body in the Department of Employment created in 1973, under the Conservative government led by Edward Heath. Its remit was to coordinate employment and training services at a time of rising unemployment in the U.K. The Job Creation Programme within the MCS was intended to address specifically youth and graduate employment. Many U.K. museums benefitted from this scheme where the government offered funding to potential employers, subject to conditions, to take on trainee staff, many of whom went on to successful careers in the museum and heritage sector.
39. Dick Hendry (1942-2015); see his obituary at https://winners.taxidermy.org.uk/influential-members/past/dick-hendry/ Accessed 17th June 2024.
40. In 2000, the Zoology curator role was adjusted to accommodate a measure of management and care of the anatomy and pathology collections. This was formalised into a 0.2 FTE portion of the Zoology post in 2021.
41. Directors of the Hunterian Museum:
    Professor Frank Willett (1976-1990)
    Professor Macolm McLeod (1990-1999)
    Mr Alf Hatton (1999-2001)
    Dr Evelyn Silber (2001-2006)
    Mr Ewen Smith (2006-2010)
    Dr David Gaimster (2010-2017)
    Mr Steph Scholten (2017-present)
42. Governance arrangements for the Hunterian have changed over time. The Regius Chairs or Heads of Department of cognate disciplines now sit on the Hunterian Academic Advisory Board.
43. John Harrison subsequently worked at the Powell-Cotton Museum in Kent, later becoming a freelance museum consultant in the U.S.A.
44. Ann Nicol works as a freelance consultant across a wide variety of U.K. heritage organisations.
45. Cathy Horsley (neé Fielder) now works as a conservation officer for the U.K. charity the Bumblebee Conservation Trust.
46. Moya Burns went on to a PhD at Oxford University and now is associate professor in Ecology and Environmental Science at the University of Leicester.
47. Information on this scheme is available from Museums and Galleries Scotland, the government body responsible for Scotland's museum sector (https://www.museumsgalleriesscotland.org.uk/museum-accreditation/).
48. Information on this scheme is available form Museums and Galleries Scotland, the government body responsible for Scotland's museum sector (https://www.museumsgalleriesscotland.org.uk/recognition/).
49. The Global Biodiversity Information Facility (GBIF) is an international network and data infrastructure funded by the world's governments and aimed at providing anyone, anywhere, open access to data about all types of life on Earth (https://www.gbif.org/).

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THE FLOURISHING OF GLASGOW ZOOLOGY: 1973-2023

Chairs, buildings, teaching, outreach and social life

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ABSTRACT

This article takes the arrival of John Graham Kerr (JGK) in 1902 as its starting point, but mainly examines developments and activities in the University of Glasgow's Zoology Department and successor structures following the first 50 years (described in the set of articles titled *University of Glasgow Department of Zoology 1923-1973*). The topics here cover 50 years of substantial change in: (a) chairs, headships, re-organisations from department to division to institute to school; (b) the buildings, not only the original Zoology building and the many alterations it has undergone, but additional ones, some short-lived, others long-term; (c) teaching of undergraduates, including the courses delivered, how they have changed and diversified, and student numbers; (d) postgraduate education, both research degrees and taught masters, including numbers; (e) outreach - taking Zoology outwith the University, an activity JGK pioneered; (f) social life: being a member of Glasgow Zoology is not all work! Specific aspects of Glasgow Zoology, especially research themes, are covered in a subsequent set of short articles.

INTRODUCTION

It is perhaps a little cheeky to invoke the city's motto - *Let Glasgow Flourish* - for this section on the history of Glasgow Zoology, but I think that the expansion and development of Zoology at the University of Glasgow over the last 50 years make it appropriate as an image, especially in light of the city's coat of arms with its tree, bird and fish. This first article covers the chairs and departmental re-organisations, the buildings, teaching, both undergraduate and postgraduate, outreach, and finally the lighter aspects of life in Zoology.

CHAIRS AND HEADS OF DEPARTMENT, DIVISION, INSTITUTE AND SCHOOL

Traditionally, Regius Professors were appointed for life, and acted as head of department (Sir D'Arcy Thompson died in post as Regius Professor of Natural History at St. Andrews, aged 88). In the late 1970s, the University of Glasgow allowed the separation of the administrative duties of head of department from the role of appointed professor. In 1979, David Newth demitted office as head of Zoology and became Dean of the Faculty of Science, retiring just two years later to Hell's Glen, Lochgoilhead in Argyll; his health was not good and he died in 1988. Latterly, he made valuable contributions to wildlife conservation as chair of the Nature Conservancy Council's advisory committee on science.

Keith Vickerman was promoted to professor and was appointed head of department to replace Newth in 1979. The University had agreed years earlier to establish a second chair in Zoology, but had not actually filled the post until Vickerman's appointment in 1979. In 1984, Vickerman was appointed to the Regius Chair, and David Crompton moved from Cambridge to take up the second chair which was now named after Graham Kerr. Vickerman remained as Regius Professor until his retirement in 1998. During his tenure, he was elected Fellow of the Royal Society, a rare accolade for a Glasgow scientist at that time.

In 1985, Stephen Phillips became head of department. The job was now a four-year, once-renewable appointment, made by the University but with departmental members consulted on the suitability of candidates, and not necessarily reserved to a person with professorial status. This made the headship a more manageable task. Around this time, the University introduced clear and transparent criteria for promotions at all levels, including to professor, and the proportion of promoted academics began to rise.

After Vickerman's retirement, there was no Regius Professor, until Pat Monaghan was appointed in 2013, a gap of 15 years. She remains in post, but there has been no appointment to the Graham Kerr chair since Crompton's retirement in 2000. After the re-organisations described in the next section, the headship was of a Division or Institute or School, rather than of a department, and the duties altered as certain responsibilities were devolved to a centralised administration.

DEPARTMENTAL RE-ORGANISATIONS

The Faculty of Science at the University of Glasgow arose from the reforms to the four ancient Scottish Universities recommended by the Royal Commission led by Thomas Henry Huxley in 1877, followed by the Universities (Scotland) Act of 1889, and was formalised in 1893. Its centenary was celebrated both by events and publications: Thomson (1993) and Downie & Stewart

(1993). The Department of Zoology was established in 1903, following the separation of geology from the previous single subject of natural history (at Glasgow, botany was never part of natural history as an academic subject, because botany was regarded as an adjunct to medicine).

By the mid-1990s, serious change was in the air. The biological sciences existed as a multitude of smallish departments located either in the Faculty of Science, or Medicine, or both. The fragmented structure was thought to be disadvantageous in the struggle for resources, and in maximising our research potential. There followed a series of convulsive re-organisations affecting administration, teaching and research: this process may not be at an end, even in 2024.

Focusing here on the impacts of these changes on zoologists, the first re-organisation placed most Zoology staff in a new Division of Environmental and Evolutionary Biology (DEEB) along with a small number of plant ecologists; parasitologists were moved to a separate Division of Infection and Immunity, along with immunologists and microbiologists; and comparative physiologists were united with neurobiologists and human physiologists (Neuroscience and Biomedical Systems- NABS). These arrangements broke up many longstanding professional relationships and were deeply upsetting for some. They did not even last long: Keith Vickerman argued that, as Regius Professor of Zoology, his place was in the Zoology building, not elsewhere. The over-arching structure was now the Institute of Biomedical and Life Sciences (IBLS), which soon morphed into the Faculty of Biomedical and Life Sciences, separate from the other sciences. In addition to the subject-specific Divisions, two educational schools were established: the Undergraduate School and the Graduate School. Their role was to establish common patterns of teaching and training across the Institute, and to provide a system for coping with the increasingly important external regulatory procedures affecting higher education, such as the Teaching Quality Assessments (TQA).

This structure lasted for about a decade, and was replaced in 2010 by a root and branch transformation of the University's structure with the replacement of the faculty system by a set of Colleges, each with a director appointed by the University's Principal. Biologists were transferred to a College of Medicine, Veterinary Medicine and Life Sciences (MVLS). An overt aim of this re-organisation was a separation of staff into research institutes where teaching would be a minimal activity, with the remaining staff expected to do little research, but the bulk of the teaching. "Research-active" zoologists were members of the Institute of Biodiversity, Animal Health and Comparative Medicine; those focusing on teaching were assigned administratively to the School of Life Sciences. The tensions created by this arrangement festered for another decade, until a further re-organisation in 2022. Zoologists are now located in a School of Biodiversity, One Health and Veterinary Medicine: although some staff focus more on teaching than on research, this is no longer a rigid arrangement. One positive result of the past re-organisations is the rise in importance of the field of "One Health" bringing together parasitologists and veterinarians with interests in animal and human health interactions.

I remember years ago seeing a postcard in a colleague's office giving the text of a comment on re-organisations, purportedly written by an ancient Roman soldier Gaius Petronius Arbiter (but actually now attributed to American writer Charles Ogburn in 1957!): "… we tend to meet any situation by re-organising, and a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency, and demoralisation". I leave others to judge whether or not the biological sciences re-organisations described accord with Ogburn's cynical view.

THE BUILDINGS

Introduction

In 1973, the staff of the Zoology Department were housed in four locations: the Zoology building on the Gilmorehill campus; the Field Station at Rowardennan; the Wellcome Parasitology Laboratory at Garscube estate; and the Developmental Biology Unit at Horselethill. A remarkably detailed article in *Nature* (Anon., 1965) had described the setting up of the Electron Microscope unit and behaviour laboratory in the basement of the Zoology building, the Electrophysiology unit in the yard, the building of the Field Station at Loch Lomond, and the Wellcome Unit for experimental parasitology at Garscube, all over the last few years. The need for some of these additional facilities arose from the rapid rise in staff and student numbers during C.M. Yonge's and D.R. Newth's periods as head of department. As noted by Vickerman (1993), Newth had a policy of maintaining groups of at least three members of academic staff in each subject area (developmental biology, parasitology etc.) and staff numbers rose from 18 to 34 during the 1970s.

The Developmental Biology Unit was relatively short-lived as part of the Zoology Department, opening in 1973 and closing two decades later: it was housed in one of two University-owned buildings at the junction of Dundonald and Horselethill Roads in the Hyndland area, the other building accommodating the Department of Oncology. See my article on Developmental Biology later in this Section. Staff retirements in the early 1990s led to closure of the unit. However, the building was invaluable following the fire in 1988 (see later article by Stephen Phillips) as a refuge for staff and equipment. It later became the Department of General Practice in the Medical School. The Field Station has a complex history (see later article by Colin Adams). The Wellcome Laboratories for Experimental Parasitology are described in the later article by Stephen Phillips.

The Zoology Building itself has been in a state of flux since the 1940s. Yonge (1973) described the changes made during his time. Events since then are now outlined, starting from the basement up.

Basement
In the 1970s, the basement contained the museum store, the departmental stores (equipment, chemicals, stationery), the electron microscope unit, and the photography unit. Since then, the museum collections have moved to new facilities in the Kelvin Hall. The electron microscopes have moved to a College facility in the Joseph Black building (previously called Chemistry); departmental stores have been consolidated into a College facility too, as have photographic and graphics facilities. The space freed up by these moves has been converted gradually to house a set of marine and freshwater aquaria.

Ground floor
The changes to the Museum are described in a later article by Maggie Reilly. In Yonge's time, an annexe was constructed on the west side of the building for the use of the agricultural zoologists. A lack of recruitment and retirements led to the closure of this group by the mid-1990s. The annexe was demolished and replaced by an animal house for the College, with a set of Zoology offices and a seminar room on the upper floors. In the yard, on the south side of the building, a structure was built in Yonge's time to act as an animal house for the parasitologists. Following their move to Garscube, this space was refurbished as an electrophysiology laboratory; then the electrophysiologists moved to a laboratory constructed from one side of the museum, and Vickerman's protozoology group replaced them in the yard. Later still, the building was occupied by Peter Meadows' biosedimentology group. Most recently, it has returned to being an animal house, full of zebra finches, with other buildings filling up the yard to house more finches, and some amphibians and lizards.

Upper level
Early in Newth's time, a "roof laboratory" was constructed above the museum. Much of this new space was devoted to facilities for experimental and comparative physiology, with the rest of the space given to offices. On a Friday night in February 1988, there occurred the most dramatic event in the building's history: a fire broke out in the roof laboratory. The flames could be seen for miles around, and the disaster made the national television news. The water used to extinguish the blaze leaked into the museum below and threatened many of the specimens (recently refurbished). Next morning, stunned staff assembled to hear head of department Stephen Phillips describe how we were going to cope, and that we would teach, as normal, on Monday morning (which we did!). My office had been one of those damaged by the fire: remarkably, documents stored in closed filing cabinets did not burn, presumably owing to the lack of oxygen; they emerged charred but essentially intact. For more on the fire, see later articles by Stephen Phillips, Maggie Reilly and Douglas Neil. A new roof laboratory was then constructed to a much higher standard than the original, and was opened by the Secretary of State for Scotland in June 1991.

In the 1990s, the University decided to name buildings after eminent figures associated with them, rather than by subjects. In Zoology's case, the obvious choice was to name it after Sir John Graham Kerr: this was achieved in a naming ceremony on 24th May 1995, where JGK's son Adam unveiled a commemorative plaque which is now located beneath JGK's portrait in the upper foyer.

TEACHING: UNDERGRADUATES
JGK regarded teaching undergraduates as his primary activity. As the department grew and developed, tensions arose between staff who wished to prioritise research and those who continued to focus mainly on undergraduate teaching. The frustrations felt by some eminent researchers arising from the high teaching loads are well expressed by Vickerman (1993). Here, I describe some of the main developments in teaching over the last five decades.

Medical teaching
Medical teaching was JGK's main focus, since most of his students were first year medical students being taught the fundamentals of biology. From the 1960s to early 1990s, medical teaching remained a major part of the department's responsibilities. S.A. Barnett's textbook (Barnett, 1957; followed by another four editions), based on the course, was a major output of the curriculum taught. Everything changed following the publication of the report *To-morrow's Doctors* (GMC, 1993), which called for major changes in both the curriculum and the general approach to teaching medicine. The University of Glasgow responded by creating a Medical School, for which a new building was constructed, and by totally re-designing the undergraduate curriculum and way of teaching. Formal lectures were largely replaced by the concept of problem-based learning in small groups. This involved the creation of new teaching units and the training of staff to act as facilitators rather than as lecturers. To avoid continual grumbling about what was being lost from the old curriculum, many of the staff brought in to teach in the new way were deliberately chosen for their lack of involvement with the old course! I was one of these staff, and was entrusted with designing the first five-week unit of first year, intended to set the tone and establish the method of teaching and learning: we decided to start with wounds, wound healing and wound treatment. In addition to the main topic blocks, the new curriculum allowed students to take so-called five-week special study modules (SSM) which need not be on core medical topics. Many students chose SSMs in foreign languages and other non-medical subjects. In Zoology, we designed and taught an SSM on *Evolution in health and disease* (Downie, 2004 a,b): the idea for this coincided with the publication of the seminal text by Nesse & Williams (1995).

First year biology
Until the late 1960s first year science students at Glasgow University could choose to take ordinary courses in Zoology and/or Botany. However, at school level, biology had become an integrated subject, and David Newth argued for such a unified course at university too. Biology-1, taught by staff from the

departments of Zoology, Botany, Cell Biology and Genetics, began in 1969 under the leadership of parasitologist Adrian Hopkins, a teacher of considerable charisma. In 1970, the locus of the course moved to the newly-constructed Boyd Orr Building, designed for first year science teaching, with a set of modern teaching laboratories (John Boyd Orr, Nobel laureate for his work in the United Nations Food and Agricultural Organisation, had been taught biology by JGK before the First World War). This move freed up space in the Zoology building, and allowed for a huge expansion in first year biology student numbers, soon rising above 600, and now 800.

As Newth (1973) mentions, the Nuffield Foundation Inter-University Biology teaching project funded a collaboration between Zoology and the Department of Education. The result of this project was the creation of a set of self-instructional biology tape/slide programmes, based on the principles of programmed learning set out by William Dunn of the University's Department of Education, plus the establishment of a self-instructional biology laboratory on the top floor of the Boyd Orr Building, directed initially by Gaye Manwaring, who moved to the University of Dundee when the Nuffield funding ran out. The concept behind this set-up was the provision of a wide range of resources aimed at meeting the different learning styles of students. A set of the self-instructional programmes was published by Longmans. The self-instructional biology unit also permitted some original thinking on ways to improve teaching in biology (Downie & Maden, 1981).

Other first year courses

David Newth regarded biology as having a generally civilising influence, and felt all students should have the opportunity to study it. He stimulated the development of a Human Biology course for arts and social science students, taught from the mid-1970s, and this was well-regarded by students who appreciated the discussion-based format of many of the laboratory sessions. A later development was a response to growing concerns over the environment: Environmental Science-1 brought together staff from Zoology, Chemistry and Geology. Later re-organisations reduced this to Environmental Biology-1, still delivered.

Second year (level 2)

Until the changes of the mid 1990s, zoologists were involved in the delivery of three level-2 courses: Zoology-2 acted as the main qualifying course for Honours in Zoology, and provided a survey of the animal kingdom, accompanied by a showcase of the special topics offered at higher levels such as animal behaviour, parasitology etc. Applied Biology-2 was the main qualifying course for the Honours course in Agricultural Zoology, but also provided coverage of applications such as animal welfare and conservation science. Marine Science-2 was created for the large numbers of students interested in the marine environment, and was taught by zoologists, botanists and marine engineers, a truly inter-disciplinary course.

The creation of IBLS stimulated a re-think of level-2 teaching. Under the direction of biochemist Ailsa Campbell, the concept was that the core areas of each biological discipline should be presented, but also that cross-disciplinary topics should be available, with staff encouraged to be innovative. Each course was worth 10 credits in a 120-credit year, so students generally studied 12 courses, with a small number acting as prescribed qualifying course for each Honours course. The core courses for zoology Honours were Animal Diversity and Conservation Biology. Zoology staff also contributed to Neuroscience and Behaviour, Reproduction and Development, Evolutionary Biology, and Extreme Biology.

Not everyone on the staff liked this system: it encouraged cross-disciplinary thinking, but some complained that this was at the expense of students learning the fundamentals of their eventual discipline. A later re-organisation created a larger component of core for each main area, reducing student choice.

Honours courses

When JGK arrived in Glasgow, the Honours BSc degree required the study of seven subjects, three of them to a higher level. Under "new" regulations from 1921, the BSc degree was offered in two options, Ordinary and Honours. The Ordinary degree extended over at least three sessions and included five subjects, two of which were studied for at least for two sessions (later named Ordinary and Higher Ordinary levels, then simply levels 1 and 2). The Honours degree required the study of four subjects, one of which would be studied for three, or more usually four sessions. So the Honours degree involved less breadth but more depth than the Ordinary (Thomson, 1993). Students who had performed well in qualifying courses during the first two sessions could then be accepted into the Honours course. The two sessions of the Honours curriculum were examined in the Finals examinations, a daunting set of papers which could ask questions on topics covered throughout the four years. Students could be assessed during the Honours years, but these interim assessments did not "count" towards the final degree classification. Traditionally, the two Honours years of the Zoology degree involved advanced coverage of the animal kingdom, invertebrates one year, vertebrates the other, with successive cohorts of students covering them in alternate orders over the two years. In the 1970s, this system was altered to include a qualifying examination at the end of third year which allowed students to graduate with what was called an Advanced Ordinary degree. In addition, the coverage of the animal kingdom was concentrated into level 3, and final year altered to allow focus on a special subject (such as freshwater ecology, or animal behaviour) plus a research project. The research project allowed students to tackle a piece of genuine research, unlike projects at school level, where tried and tested projects are recycled year after year. This meant that on some occasions, the results led to a publication. When projects were first brought in, there was some discussion over their assessment: some staff argued that the closeness of the interaction between

supervisor and student made assessment problematic. However, for most staff, and students, the time investment in the project argued strongly for the gaining of some credit towards the degree classification, and this argument prevailed. The assessment included an element based on the supervisor's judgment of the student's performance on the practical work of the project, and a larger element based on two independent assessments of the project report.

For the Department of Zoology, the core course was Honours in Zoology, and this remains the course studied by the majority of our undergraduates. However, after the Second World War, a new Honours course in Agricultural Zoology was introduced, with the first graduates in 1949. Numbers choosing this course were never large (2.2 per year over the years 1949-1973, and similar thereafter until the course closed: Table 1), but students were generally of high quality and career focused, especially on the agrichemicals industry. One of our graduates rose to be CEO of the multinational company Monsanto. Unfortunately, staff retirements, with no replacement, linked to the low student numbers, led to the closure of the course in the late 1980s.

In the early 1970s, Newth saw an opportunity to attract medical and veterinary students into our courses, as "intercalated" degrees. This option allowed medical, dental and veterinary students, after successful completion of the first two years of their course, to move into the Faculty of Science and study a relevant course for one or two years, emerging with a degree in the subject chosen before returning to their original course. Newth and colleagues created two new degree programmes: Parasitology and Animal Developmental Biology (see later articles on these subjects). Science Faculty regulations required that these courses should also be available to Science students, and, indeed, the Zoology course also became available as an intercalated degree. Not too surprisingly, over the years, Zoology attracted a few veterinary students interested in "exotic" animals, but no medical students. After *Tomorrow's Doctors* (1993), and the resulting changes to medical teaching, the two-year intercalated degree was withdrawn, and only a single year option was offered.

In the early 1980s, David Crompton encouraged the creation of a new Honours course to take advantage of several strengths: our access to the Clyde marine and estuarine environments including the marine station at Millport; the Rowardennan field station on Loch Lomond, the U.K.'s largest freshwater lake; the presence of several researchers in aquaculture, especially fish welfare aspects. Other universities already taught degrees in marine biology, but Glasgow was unique in uniting all aquatic environments in our Aquatic Bioscience degree (later re-named Marine and Freshwater Biology), taught from 1988. In terms of student numbers, this was a success from the start (Table 1).

The Zoology Honours degree course has been taught since the new regulations began in 1921. Numbers of graduates were initially low (2.0 per year in the 23 years from 1924 to 1946, with no graduates in some years), but increased after the Second World War (4.5 per year in the period 1960-1965) and really took off after the arrival of David Newth (13.3 per year, 1966-1971, later rising to over 50 per year: Table 1). To accommodate the increased numbers and to allow students to specialise according to their interests, the Junior Honours (level-3) year included options at various points, and these were helpful in providing courses for the new degrees, such as Parasitology. Therefore, students on each degree were sometimes taught on their own and sometimes in combined classes with students on one or other of the Zoology-related programmes. Table 2 shows the level 3 course structure for the four programmes as delivered in 1995-1996.

Such diversification clearly required more academic staff. As Vickerman (1993) has described, the academic staff complement in Zoology increased from 18 to 34 in the 1970s. It was rumoured that, at its peak, Glasgow Zoology was the largest such department in Europe. Unfortunately, as student numbers continued to rise, funding did not follow, and the increased student/staff ratios created strains, also described by Vickerman.

Later, after the formation of IBLS, the Undergraduate School attempted to create common patterns of Honours teaching across all bioscience degrees: the structure agreed was that final year should be divided into four five-week optional courses, plus a research project. Table 3 shows the Zoology-related course options available in 1995-1996. More recently, under the College, this has been slightly modified, but the general

	Programme					
Decade	**Zoology**	**AZ**	**MFB**	**DB**	**Parasitology**	**Total**
1970s	25.8	2.8	-	2.0	4.0	34.6
1980s	30.1	3.1	-	2.8	5.0	51.0
1990s	35.8	-	14.4	7.8	18.7	76.7
2000s	47.2	-	12.1	-	10.1	69.4
2010s	55.6	-	19.4	-	9.9	84.9

Table 1. Average annual numbers of Honours graduates in Zoology and related degree programmes by decade. Raw data supplied by Guilhem Vadon and Emily Howie. The final graduates in Agricultural Zoology were in 1989 and in Developmental Biology in 1998; Parasitology ceased to be a separate programme in 2020. Programme name changes: Animal Developmental Biology lost the word "animal" in 1986; Aquatic Bioscience became Marine and Freshwater Biology in 2012. AZ, Agricultural Zoology; MFB, Marine and Freshwater Biology; DB, Developmental Biology.

Zoology
Term 1: Biodiversity, Computing, Microscopy, Freshwater and Terrestrial Ecology Field Course (Rowardennan), Vertebrate Biology OR Biology of Parasites, Biometry.
Term 2: Animal Physiology OR Immunology and Immunoparasitology, Biometry (continued), Reproductive Biology OR Pelagic and Benthic Processes OR Molecular and Biochemical Parasitology with Chemotherapy.
Easter vacation: Marine Biology Field Course (Millport).
Term 3: Arthropods and Vectors.
Aquatic Bioscience
Pre-term 1: Marine Biology Field Course (Millport).
Term 1: Biodiversity and Aquatic Environments, Computing, Vertebrate Biology, Biometry.
Term 2: Animal Physiology, Biometry (continued), Pelagic and Benthic Processes.
Term 3: Water Quality, Freshwater Field Course (Rowardennan).
Developmental Biology
Term 1: Cells and Tissues, Computing, Developmental Processes, Molecular Biology of Development.
Term 2: Vertebrate Organ System Development, Reproductive Biology.
Term 3: Fetal-Maternal Relations, Evolution of Developmental Systems.
Parasitology
Term 1: Biodiversity, Computing, Microscopy, Biology of Parasites, Biometry.
Term 2: Immunology and Immunoparasitology, Biometry (continued), Molecular and Biochemical Parasitology with Chemotherapy.
Term 3: Arthropods and Vectors.

Table 2. Course content of Zoology and related degree programmes at level 3 in 1995-1996. In addition to lectures, practicals and field courses or a discussion weekend, programmes included small group tutorials. In 1995-96, the University teaching year contained two ten-week terms and a five-week third term. A few years later, the University changed to a two-semester teaching year.

Term 1
Weeks 1-5: Marine ecosystems; Biochemical Parasitology; Animal Behaviour.
Weeks 6-10: Cellular Morphogenesis; Physiological ecology; Parasitism and Disease; Behavioural Neurobiology; Insect Anatomy and Systematics.
Term 2
Weeks 1-5: Freshwater Ecology; Immunology of Parasitic Infections; Behavioural Ecology. Weeks 6-10: Fisheries and Aquaculture; Molecular Parasitology; Applications of Ecological Principles.

Table 3. Level 4 optional courses (five weeks each, 30 h contact) offered by Zoology, 1995-1996.

principle has been maintained. For many years, the Zoology Department published an annual *Students' Guide to Honours Courses*, distributed to all staff and students, detailing the timetables for all courses. The *Guides* had attractive covers featuring zoological subjects (Fig. 1).

Work placement year

Another IBLS innovation, created by David Crompton, was the introduction in 1996-97 of a work placement year. Many universities were dealing with the criticism that degrees were too theoretical and divorced from the world of work by incorporating work placement components of varying sorts. IBLS decided on a full year's placement, taken between the two years of the Honours programme, and that the placement should involve a research project. Because the work-places offering placements would look after the students for a whole year, IBLS decided that only good quality students would be permitted to go on placement. Therefore, students who have good grades after years 1 and 2 are invited to apply for the placement year. They are then selected on the basis of their written application and a rigorous interview. After this, selected students have to organise their placement, with the assistance of staff. For Zoology-related degrees, organisations offering placements include conservation charities, zoos, museums, government agencies, some companies and other University departments. Placements can be at home or abroad. Members of Glasgow's staff act as mentors to each placement student during the year away. The inclusion of this extra assessed year converted the Honours degree into a five-year Master in Science (MSci) qualification, with the placement year assessed on the basis of the student's written report, an oral examination and a review essay. The placement location supervisor sends a report on the student's performance, but this does not contribute to the grade. In the five years 2020-2024, 26 Zoology and ten Marine and Freshwater Biology students have gone on placement, from Iceland to New Zealand and most places between. In session 2023-24, three are in Australia, one at Chester Zoo, one in Hawai'i, one with the RSPB in Edinburgh, and one working on urban biodiversity in Glasgow. The departure of the U.K. from the European Union has made the organisation of placements elsewhere in Europe highly problematic because of the loss of the right to freedom of movement. Funding for the placement year is challenging in Zoology-related organisations which often lack resources. The placement students often earn their keep by working part-time, say in the organisation's shop, while carrying out their

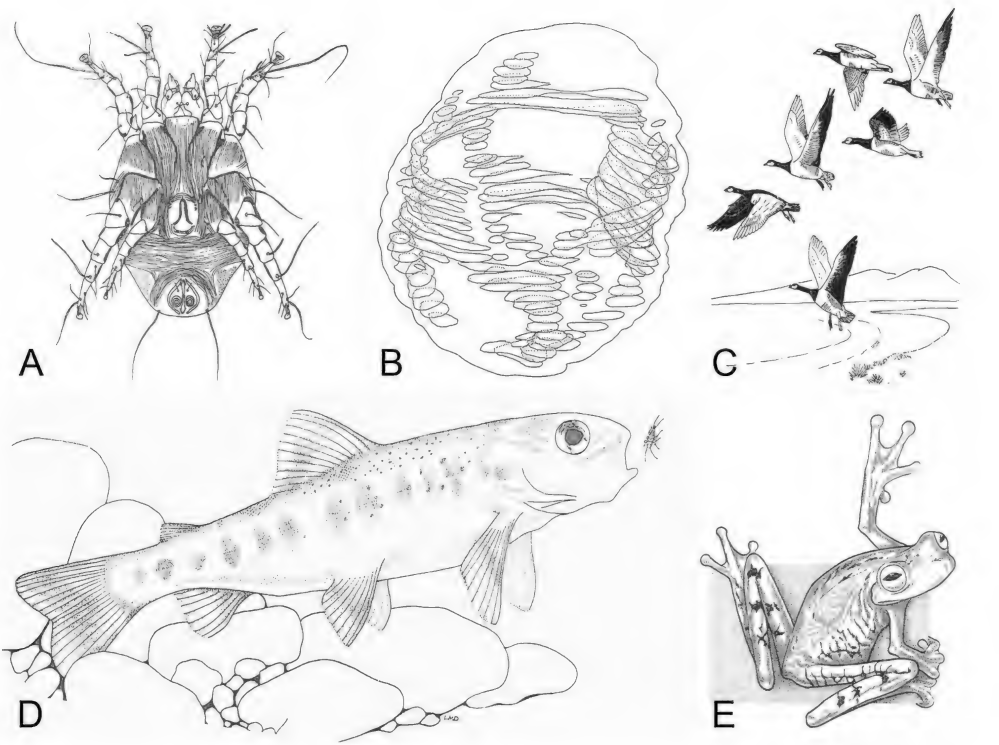

Fig. 1. Cover illustrations from Zoology Students' Guides 1984-87. (A) Ventral view of a male European house dust mite: these mites are responsible for allergic disorders in people, and can also transmit a bacterial disease; departmental researchers developed an assay for monitoring levels of mite allergens in the homes of chronic asthmatics. (B) computer-aided reconstruction of the mitochondrion of a *Leishmania* parasite: this parasite causes skin ulcers in Central American forest workers; Glasgow research worked on how the parasites evade the host immune response. (C) Barnacle geese (*Branta leucopsis*), which breed in the high Arctic and overwinter in Scotland: on Islay, high numbers of the geese result in conflicts with farmers which Departmental researchers found ways to alleviate. (D) A salmon parr feeding on an invertebrate: Departmental research investigated why some parr stop feeding early in life, while others continue for up to four years at this stage before migrating to the sea. (E) A tree frog attached to a vertical surface: when this species was studied in the 1990s, it was named *Hyla crepitans*; after taxonomic revisions, it has become *Boana xerophylla*; work on 12 Trinidad species by Jon Barnes and expedition students showed that frogs stick by means of wet adhesion.

research project the rest of the time. Placement students tend to be highly motivated, and their reports often form the basis of later published papers; a high proportion of placement students progress to PhD programmes.

Change and innovation in Zoology courses

As described in *Gallery,* JGK was an innovator in his approach to Zoology education: he overturned tradition by starting with Protozoa, especially those of medical importance (as shown in *Dr Flo's Lecture Notes*, this volume), and he was particularly keen on the educational role of a well-organised museum. In the earlier section on First year biology, I described the Nuffield-funded project on self-instructional facilities. Here, I describe some of the other innovations brought into Glasgow Zoology teaching.

Dissection and its alternatives

Comparative anatomy was the core of Zoology in JGK's time. In the 1960s, dissection of fresh or preserved specimens remained a crucial part of the laboratory course at all levels. Walter Edgar remembers being provided with a small crocodile to dissect in final year, along with a hacksaw to cut through the tough skin! In my year, each student was given a tortoise, with instructions to kill and dissect it; most of us released them in our gardens. The practice of providing students with exotic and possibly endangered animals to dissect is now long gone. From 1970, in first year biology, dissection of a laboratory rat, with students working in pairs, was structured as an investigation of mammalian structure and function, including simple experiments on the lungs, stomach and kidneys. However, by the 1980s, significant numbers of students were unhappy over the killing of animals specifically for their education (the dissection of a sheep's heart and lungs did not generate the same anxiety, because it used slaughterhouse material, where the animals had been killed for food).

Our solution was the offer of an opt-out, where students could choose to do the work of the class using a model rat, thereby saving an animal's life. Students made their choice following discussion of the issues with their peers and a class demonstrator, thereby providing an experience of practical ethical decision-making. Over five years, about 10% of students chose to opt-out, though many of them chose also to watch the later stages of the dissection once they had finished working on the model rat (Downie & Meadows, 1995).

Bioethics education

Experience with the dissection opt-out and other issues concerning the uses of animals in education led to a Marie Curie Grant-aided education research project that introduced ethical decision-making into all branches of biological science education at the University of Glasgow (Downie & Clarkeburn, 2005). Each speciality had its own set of issues: wildlife conservation ethics and animal welfare, for example, for zoologists; but there was also a focus on professional ethics, now usually termed "research integrity". The development of our courses in this area coincided with the activities of the Higher Education Academy's biology special subject group on bioethics, and the Quality Assurance Agency's *Benchmark on the Biosciences* (2002; most recent version 2023), which includes strong recommendations on the role of ethics in biosciences higher education.

Discussion-based teaching

Bioethics is largely taught using scenario-based discussions: students in small groups discuss a particular problem, then report back to a plenary, allowing comparison of viewpoints. Zoology at Glasgow was early in its use of discussion-based methods. I recall a frankly terrifying course on concepts in animal behaviour, designed by Tony Barnett, in the second year course I studied in 1964. Each day, we were given a short paper to read and think about: one was on Clever Hans, a horse that was reputed to be able to count; another was on the nature of consciousness, still a notoriously hard problem. We had been used to sitting in rows in the lecture theatre, with the lecturer on a podium at the front. But for the first of these "free group discussions", the chairs were in a circle and when Barnett came in, he sat at a chair, offered us "good morning" but said nothing more, and waited for us to talk. After an hour of excruciating, desultory comments, Barnett handed out the next topic, and left. We got the message: we were seriously expected to be prepared and to discuss the topic, not to rely on the lecturer, and the discussions grew more lively and even coherent. David Newth was also keen on discussion, and introduced a weekend residency during the first term of level 3 at The Burn, a country house in Edzell, Angus. I recall the female students complaining that we should have told them how grand it was, so that they would have known to bring their best clothes! The discussion topics were mostly chosen by staff, but the students were asked to come up with one. Memorably one year, they decided on "What is normality?" and set R.D. Laing's *The Divided Self* as preparatory reading. After the discussion, late on the Saturday night, and somewhat fuelled by drinks from the bar and the country house atmosphere, a group decided to hold a séance: the next morning we found a group of scared, pale students, convinced that the table they had sat round had "moved" and that some of them had seen "something ghostly" move on the lawn outside! As the class sizes increased, the resources and space needed for these weekends became hard to find, and they were regretfully discontinued, except for the Developmental Biology degree which did not offer the class-bonding opportunities provided by a field course.

Field courses and fieldwork methods

Field courses in marine biology (based at Millport) and freshwater/terrestrial ecology (based at Loch Lomond) have long been a component of the undergraduate programmes in Zoology and related degrees. Geoff Moore tells me that the earliest record of a University of Glasgow marine course at Millport, recorded in the SMBA annual reports, dates from Easter 1922, a six-day course run by J.S. Dunkerly. In later years, staff in charge of the Easter course included Margaret Jepps and G.S. Carter. The Loch Lomond course, begun after the Second World War, could accommodate only small numbers in the original field station, but Rowardennan provided comfort and space for substantial residential courses. In more recent years, additional field courses have been provided as options, designed to give experience of biodiversity abroad. These have been located (1) at the Red Sea in Egypt (or for a time in Tobago, West Indies) for coral reef studies: running for over 30 years, this is probably the longest-running such course organised by a U.K. university; (2) in Ecuador for neotropical forests; and (3) most recently in Kenya for tropical terrestrial work. Field courses not only provide direct experience of biodiversity, they also allow the learning of fieldwork methods. Fieldwork does not have to take students far away from the University campus: daytrips to Possil Marsh Nature Reserve and, even closer, to Kelvingrove Park have provided valuable experience. An innovative exercise used for many years with level 2 students was a mark-recapture experiment based on Glasgow taxicabs. The number-plates were the marks, as well as providing age data, and taxi ranks were the sample points. One year, students with their clip-boards were regarded with suspicion by the drivers, who thought they were City Council spies! An issue with fieldwork is that it may be inaccessible to students with mobility problems. In addition, it is difficult for students to catch up with fieldwork if they have missed the actual experience through illness. With funding from the U.K.'s Joint Information Systems Committee (JISC), Ross McLeod created a set of virtual field course experiences that can help with this problem, as well as providing revision opportunities.

Transferable/graduate skills

When I was a Zoology undergraduate in the mid-1960s, transferable skills were never mentioned, as far as I was aware. We were expected to learn as much as we could about the subject and practice of Zoology, including laboratory and field work and the writing of reports on our findings. Some of this involved learning skills like dissection, some of it small scale investigations. In our

Junior Honours tutorials, which were weekly one-to-one hour-long sessions with a member of staff, researching information and presenting it in essay form were the essential skills learned. The tutorials, as well as the free-group discussions mentioned earlier, were excellent training in thinking clearly about scientific terms and their meaning. Data analysis was very basic: we all took a course in genetics where chi-squared analysis was introduced, and that was about it. There was no course in scientific method, although we did receive a hard lesson on it. As a laboratory test, we were given dead cockroaches which had been fed food containing the indicator dye phenol red (red when neutral/alkaline, yellow/colourless when acid). We had individually to dissect these, examine the intestines, and report on the pH of the contents. Those of us who wrote that we could tell nothing without a control cockroach not fed the dye received full marks: the rest were awarded zero!

More recently, identification of the skills that characterise graduates and make them employable, irrespective of the subjects studied, have become a much bigger and overt part of higher education. These skills are often termed "transferable" because they can be employed in many kinds of occupation, including researching information, presenting it in written and oral forms, data analysis, and organisation and time management. As the inclusion of these skills has become a characteristic of all aspects of higher education, it is not specific to Zoology and will not be further explored here.

TEACHING: POSTGRADUATES

The nature of postgraduate education has evolved considerably over the years. In JGK's time, there was effectively no postgraduate teaching. Graduates who had progressed to scientific careers submitted a body of their published work, usually to the university of their first degree, in order to be considered for the higher degree of Doctor of Science. In a sample of ten Zoology DSc graduates over the period 1961-1973, the period between first degree and doctorate ranged from ten to 34 years.

Later, recent graduates were able to obtain funding to study towards the higher degree of Doctor of Philosophy (PhD), and the number submitting work for a DSc diminished. In Zoology, the work of a PhD student involved carrying out research under a supervisor, and eventually (minimum of three years) submitting the results as a thesis. This would be assessed orally by two examiners, one internal to the University, the other from another institution. The criteria for success in the PhD examination were that the examiners should judge the thesis to contain a substantial body of original research, and that the candidate should be able to defend his/her work successfully during a robust oral examination. Funding for PhD projects came from a variety of sources: mainly from the national Research Councils, but also from a range of charitable trusts and some government agencies. Although original research has remained the prime focus of PhD work, the Research Councils eventually determined that there should be taught components related to the acquisition of generic research skills: data analysis, report writing, research ethics, science communication, and also skills related to the specific research project, such as tropical fieldwork skills. Provision of the generic skills was facilitated in Glasgow by the creation of a Graduate School to administer the affairs of all IBLS postgraduate students. The number of doctoral graduates in Zoology has increased substantially over the decades (Table 4). In the 30 years from 1925-1954, there was a total of only 19 doctoral graduates, whereas in the following ten years there were 45 (predominantly PhDs) and in the next decade 65, 91% PhDs. Most recently, the annual number of PhD graduates averages 20. The recent numbers partly reflect the changed departmental organisation, but also a heavier emphasis on research training. Although academic staff were anxious about any increase in undergraduate numbers, because of the time taken away from research, this was much less of a problem for PhD training, because much of the research done would find its way into publications eventually, usually with the research student as first author and the supervisor last.

Time Period	DSc	PhD	MSc (research)
1925-54	7	12	0
1955-64	8	37	0
1965-74	6	59	13
2013-22	?	195	?

Table 4. Numbers of Higher Degree Graduates in Zoology.

The second general designation for a postgraduate degree is the Masters. It is possible to submit a piece of research as a thesis for Masters by research. This can be for part-time students unable to commit to a PhD, or for students who wish to leave a PhD programme for whatever reason, but to obtain some credit for the work they have done. The number of Masters by research graduates in Zoology has never been large. The other route to a Masters is the taught Masters degree, leading to an MSc (Master of Science) or MRes (Master of Research). Possibly confusingly, the MSc is distinct from the MSci covered earlier, an undergraduate degree including a work placement year. In 2010, the University encouraged the development of taught masters degree programmes, and a number of these are now available in the general field of Zoology (Table 5). These programmes have been successful in attracting students, especially from overseas, and act as a stepping-stone to a PhD programme for some. These taught masters courses all include coverage of research skills and a research project, as well as masters level treatment of subject-related topics. Development and delivery of these courses involved a considerable investment of staff time.

OUTREACH

JGK had considerable interest and involvement in taking Zoology beyond the University, including giving talks on radio, lectures to the Workers Educational Association (despite his conservative politics), and taking a leading role in the Royal Philosophical Society of Glasgow (see *Gallery*).

Animal Welfare Science, Ethics and Law
Applied Conservation Science
Conservation Management and African Ecosystems
Ecology and Environmental Biology
Epidemiology of Infectious Diseases and Antimicrobial Resistance
One Health and Infectious Disease
Quantitative Methods in Biodiversity, Conservation and Epidemiology
Animal Nutrition
Food Security

Table 5. Taught Masters courses available in the School of Biodiversity, 2023-24. All lead to a MSc degree, except Ecology and Environmental Biology, which leads to a Master of Research (MRes). Delivery of these courses often involves expert contributions from outside the School.

Outreach has continued to be important as can be seen from the following examples. For some years, the department offered a popular Christmas lecture to Glasgow schools, somewhat in the style of the Royal Institution Christmas lectures. Jon Barnes and Maggie Reilly put together what was called the Primary Schools Project in the 1970-1980 period: pairs of students visited a particular primary class in a Glasgow school over five or six weeks, bringing interesting specimens for the children to see and discuss. For the project, Maggie assembled a collection of less-valuable museum specimens - skulls, feathers etc. The project was well appreciated by the schools, but also benefitted the students in developing their presentation and time management skills. Members of staff have for long contributed to the courses offered by the Department of Adult and Continuing Education, both for general interest and for credit: examples include courses on animal welfare, the environmental crisis, and a day school on evolution to coincide with Darwin's bicentenary. A recent development, since 2007, is the Glasgow Science Festival, run by Zoology graduate Deborah McNeill as a ten-day event each June: zoologists have contributed interesting and innovative activities and presentations since the festival began.

The Zoology Museum is accessible to the public during weekday opening hours, and Museum staff along with other staff have also curated special events, usually held in the main galleries in the University's Gilbert Scott Building, such as animal architecture and an exhibition on overseas expeditions. Zoologists have also contributed to the Hunterian Museum's popular lunchtime lecture series.

University zoologists have long had involvement with the city's natural historian community, serving on the Council of Glasgow Natural History Society and for some decades providing space for the Society's library. A highlight of the year is the annual Blodwen Lloyd Binns lecture which brings together the University's staff and students and the Society's members to hear from one of the country's leading natural historians. In addition, the Zoology building has provided space and a venue for several of the local conservation organisations, such as Froglife, the Scottish Ornithological Club, and the Clyde River Foundation.

SOCIAL LIFE

The Zoology Department appears to have been a sociable place since earliest times, with the staff and small numbers of students taking tea together in JGK's rooms. In the Zoology Building, a room on the ground floor has long been designated the Social Room. For a time, this was specifically for the technical staff, with academics and research students having programmed breaks in the library on the upper floor, but this segregation was eventually abandoned, with all staff and postgraduates using the Social Room. In the 1970s and 1980s, the Room was staffed by a team of laboratory assistants, notably Nessie and Chrissie, and managed so successfully by a committee of senior technicians that the profits generated funded the sumptuous technicians' Christmas party, held in the decorated ground floor teaching laboratory, to which all staff and postgraduate students were invited. Sadly, retirements and cutbacks resulted in the Social Room becoming self-service only, and a long tradition of having filter coffee from the venerable Glasgow Thomson's Coffee House died out. Another tradition has been the Christmas breakfast on the last working day before the Christmas break; this could be seen as a training event for your family Christmas dinner – a huge fry-up of bacon, eggs, sausages, mushrooms, and tomatoes with morning rolls, available to all at work on that last morning. Sadly, the pandemic put an end to this tradition.

To organise other social activities, some form of "amenities" committee has long operated. Events have included Burns suppers, Hallowe'en parties (Fig. 2), ceilidhs, summer barbecues (at the Garscube campus, including races and other activities), pub-style quizzes, and sporting events: these have generally been mixed, including hockey, squash, and five-a-side football. I recall that by far the most skillful player in the final of our tournament at the Kelvin Hall one year was one of the female students. For some years, a large group of us braved the old, unimproved A9 in February for a long weekend winter sports break in caravans at Aviemore (sadly, the University abolished the mid-term holiday and made this break impracticable).

A tradition for many years now is that successful PhD vivas are celebrated by means of a specially-created cake (in the image of the student's animal: frog, bird, fish etc.) and other refreshments, with speeches in the museum. Another well-established tradition is the Christmas ornithology lecture (by a visiting speaker, often a distinguished graduate or collaborator of the department), followed by drinks, music and a feast in the museum. The musical aspect has grown from modest beginnings, starting with a small band of enthusiasts (cellist, two fiddlers, and whoever else could be dragooned to help), playing Scots traditional tunes, classics and popular songs (Fig. 3). At the Graham Kerr centenary event in November 2023, three different departmental bands performed. One wonders whether, when prospective new staff and postgraduates are

Fig. 2. Naomi Barron and Roger Downie as Trinidadian folklore characters Mama de L'eau (protector of the waters) and Papa Bois (guardian of the forests) at a mid-1990s Hallowe'en party, with Stuart Bearhop as a well-known marine biologist. (Photo: Kate Griffiths)

interviewed, they are asked what instrument they play! Drinks and food often follow talks by visiting speakers, notably after the annual Blodwen Lloyd Binns lecture (jointly organised by the department and Glasgow Natural History Society) and the Darwin lecture. And finally there is the Friday Fox which follows the short talks postgraduates give on their research on a Friday afternoon: when better to have a social in the museum?

Fig. 3. The Black Fox band in the Zoology Museum: from the left - Suzan Trienekens, Luke Powell, Pablo Burraco, Jason Matthiopoulos, Spyros Matthiopoulos and Crinan Jarrett. (Photo: Luca Nelli)

Is this level of social activity unusual in an academic department? Visitors tell us that it is, but not unique: another with a similar atmosphere is the ecology department at the Penryn campus of the University of Exeter, but many of the original staff there are Glasgow graduates! What is sure is that active social interaction of this kind contributes to a positive and happy working environment, and that must be good for productivity.

CONCLUSION

This article has covered organisational, structural and teaching aspects of Glasgow Zoology over the last 50 years, as well as outreach and social life, but has hardly touched on the diversity of research and the people involved. These and other topics are covered in the following articles.

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Reflections on my period as Head of Zoology 1985-1990

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PREAMBLE

I was always planning to follow a career as a biologist, and early in my time at Manchester Grammar School it was to be in marine biology. But, in the sixth form, our biology teacher directed us to the 1959 Reith Lectures on the radio (and published in the now defunct *The Listener*) by Peter Medawar on "The Future of Man". Medawar was an immunologist and shared the Nobel Prize for Physiology and Medicine with MacFarlane Burnett in 1960. Marine biology was ditched for Immunology and, noting that Medawar was the Jodrell Professor in Zoology at University College London, I applied to UCL to study Zoology, and was fortunate to pass the entrance exam. Medawar left at the end of my first year to become the Director of the National Institute for Medical Research (NIMR) at Mill Hill, which is now the Francis Crick Institute. One of my teachers at UCL was Keith Vickerman who later became the Regius Professor of Zoology in Glasgow and, when I was appointed Head of Zoology in 1985, I took over from Keith. Fast forward after UCL and a PhD in Cambridge, I was given my first job at NIMR (the letter from Medawar offering me a job is a prized possession) in the Division of Parasitology, Head of the Division being Frank Hawking, Stephen Hawking's father. Five years into my time at NIMR I was alerted (by Keith Vickerman) to the fact that there was a lectureship to be filled in Glasgow. I applied and was appointed in 1972 and joined the strong Parasitology group in the department. Colleagues down south, when I told them we were moving to Scotland, assumed we were moving to Edinburgh! No one of sound mind would move to Glasgow, whose reputation was based on the novel *No Mean City* by A. McArthur and H. Kingsley Long, and Billy Connolly.

I read in Haynes (2013) that John Graham Kerr, the first Regius Professor of Zoology from 1902 (the chair of Natural History being divided into chairs of Geology and Zoology) when the department inhabited the dark and damp basement below the Hunterian Museum, had agreement for his new building in 1914, but the Great War put a stop to all building. He was, we read, an exacting client who demanded minor faults in the finished building were rectified immediately. As a protozoologist myself it was of interest to read that the teaching of natural history had an emphasis on microscope work, at a time when microscopes used natural daylight to illuminate the object of investigation: a good situation with available daylight for the main teaching laboratory was essential.

In the 1970s the parasitological strength in the department of Robert Bruce, Adrian Hopkins and Keith Vickerman, was added to by the recruitment of Derek Wakelin and myself, and later Graham Coombs and Anne Lackie. This led in the mid-1970s to the establishment of a new degree in Parasitology, which became and continues to be a very successful nursery of parasitological expertise in the U.K. and beyond. The teaching on this new degree was supplemented by parasitological colleagues in the Veterinary School and the department of Pathology. The appointment of David Crompton in 1985 to the newly established Graham Kerr Chair added to the parasitological strength of the department. In the middle 1980's Derek Wakelin left for a chair in Nottingham and Adrian Hopkins retired which left the Wellcome Parasitology Laboratories vacant. The Wellcome Parasitology Laboratories at the Bearsden Garscube Campus were one of several outstations of the Zoology Department. Malcolm Kennedy and I were asked to relocate there from the Graham Kerr Building with our research groups. My research group never returned to the GKB.

During my time as Head of Zoology (1985-1990) and then as Dean of Science (1990-94), I had an office in the GKB. I cycled many miles between Garscube and Gilmorehill over those nine years. In 1994, the Life Sciences were "rationalised" with the formation of IBLS (the Institute of Biochemical and Life Sciences). The rationalisers thought it appropriate to remove the "parasitological" staff members, apart from the holders of the two appointed Chairs in the Zoology department, both parasitologists, into a new "department" of "Infection and Immunity" which also included the departments of Cell Biology and Microbiology. I was asked to become Head of Infection and Immunity in 1995 for five years. We were told to vacate the Wellcome Laboratories at Garscube and we transferred back to the main campus and were housed in the Joseph Black (Chemistry) Building. Later I and my group moved again into the Graham Davies Building. Why the appointed Chairs were not transferred into "Infection and Immunity" was never explained. This clarifies why I was only a "full time" resident of the GKB from 1972 to 1985, and from 1994 banished from the home where my heart was.

THE FIRE

On Friday February 19th 1988 at about 9 p.m., I received a call from the University security office to tell me there was a fire in the Zoology Department Roof Laboratories and it was a serious fire. The alarm had been given by two nurses in the Western Infirmary, which is across from the GKB. I jumped into my car in Milngavie and I recall pulling in on Great Western Road, by Gartnavel Hospital, to allow fire engines pass, going to fight the fire, and seeing from where I was stopped the flames reflected in the smoke billowing out into the sky above the department: a picture in my mind's eye which has lasted to this day. The fire destroyed the Roof

Laboratory, and seriously affected ten adjacent offices and an Animal House. This extension had been built on the museum roof in 1966, with the animal suite added in 1969. Ten fire engines and 50 firemen took three hours to bring the fire under control. A total of 18 teachers, research students, postdoctoral workers and technical staff worked in the extension. Damage to fabric, furniture and equipment was in 1988 worth over £1 million. The laboratory was equipped mainly for physiological, behavioural and ecological research. Ironically the flat roof of the extension had leaked from when first built but two months before the fire, at some considerable expense, it had finally been made watertight!

Loss of data by academic staff and research workers was not as serious as was first feared. Two theses, at a late stage in their compilation were, by chance, in two of the offices which escaped the worst of the conflagration, suffering serious but not mortal damage from water and smoke. Everyone in the area lost something of value. The effectiveness of steel filing cabinets, providing the drawers were securely closed, in resisting heat and water was amply demonstrated. The flammable cupboards also showed their worth, with the contents found to be intact the following morning. More unexpectedly, the contents of two deep freezers were found still frozen on Saturday and some irreplaceable research material saved.

The animal suite, in spite of sharing the partition wall in which the electrical fault causing the fire is thought to have occurred, also escaped without the demise of a single fish or bird. A combination of the skill of the fireman and a steady wind blowing away from the animal suite, must have been contributory to this. It must have been touch and go at some stage because the cage labels were scorched and ceiling light fittings melted in two animal rooms. The Home Office inspector, Jon Richmond, who was responsible for the Zoology animal houses at the time, still recounts how amazed he was that no animal came to grief.

The fire was contained to the Roof Laboratory extension but its effects in the form of water damage extended into the Museum and the surrounding research and computer laboratories below on the ground floor. The water from ten fire engines pouring continuously onto the fire for three hours had to go somewhere, and this was downwards. A total catastrophe was averted by the speedy action of the firemen in rapidly covering irreplaceable exhibits, collections and equipment with plastic sheets in the museum below before the water deluged down from above. The Zoology section of the Hunterian Museum had been painstakingly refurbished over a ten-year period and had been "reopened" by David Attenborough just 22 months before the fire. Restoration of the Museum took over a year (the section on the Museum includes photographs of the fire damage).

Members of the Zoology Department (as was!!) spent the weekend of the fire clearing and salvaging, and to good effect in that the undergraduate teaching was able to resume on time on the following Monday morning. The displaced colleagues were eventually temporarily rehoused in portacabins in the Physics car park. I asked Professor Pat Monaghan and Professor Neil Metcalfe, who are currently in the GKB and were also there in 1988, for their memories. Neil, a postdoctoral worker at the time, shared a Roof Laboratory office. Neil writes: "You phoned me that evening, telling me there was a fire, that my office was one of those affected, that there was no possibility of my doing anything that evening as the fire was not out, but that "I might like to come in in the morning" to retrieve what I could. I then spent a restless night wondering what I had lost. Early the next morning Pat and I found that virtually the entire department had turned out to help clear up. There was a real Blitz spirit. The first sight of my office was appalling – the roof completely missing, everything black and soaking – but then I realised that most of the black was soot, and that things on our desks were not actually burnt; if you peeled away the top, blackened pages then the underlying pages were readable, if soaking". In close-by offices the occupants were less fortunate with everything on desks, shelves and tables being burnt to a cinder. Neil commented on the value of the steel filing cabinets keeping their contents safe. Pat recalls that "Somebody organised a delivery of filled rolls for everybody and vegetarians were catered for. There was a real community feeling". I recall a number of Heads of Department across the university, and Aubrey Manning, Head of Zoology in Edinburgh, all contacting me and asking if there was anything they could do to help in our hour of need.

Recovery from the fire was protracted because of a combination of the GKB being a Grade 2 listed building and a lethargic Estates and Building Unit. The university's Finance Officer would calculate how much it had cost the university waiting for the Estates and Building team to arrive after the scheduled start time. The restored Roof Laboratories were formally reopened on June 29th, 1991.

CONCLUDING THOUGHTS

Notwithstanding my research laboratories were located in the Graham Kerr Building only from 1972 to 1985, and prior to retirement I had an office there from 1972 to 1994, my heart has always been in "Zoology" as we used to call the GKB. The GKB has always had a "family" feeling amongst the occupants, and we looked out for each other. In my time as Head of Department that was amply evident in the response to the fire and afterwards. And since Dan Haydon allowed me a shared office in the GKB more than ten years ago, I see nothing has changed.

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The Millport connection

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The notably high biodiversity of the Clyde Sea Area and its sheltered surroundings had been recognised by Victorian naturalists who had sensibly opted to develop a research base at Millport, Isle of Cumbrae in 1884 (Figs. 1 and 2). The First Annual Report of the University Marine Biological Station Millport (UMBSM), covering the period from 1st June 1970 to 31st July 1971, began by acknowledging the long and distinguished history of the Marine Station under the auspices of the Scottish Marine Biological Association (SMBA) and its forebears, noting the transference of control of the Marine Station to the Universities of London and Glasgow.

Fig. 1. The new Millport Marine Station, soon after construction, about 1900.

Fig. 2. The Ark, the original Millport marine station, towed to the west coast via the Forth and Clyde canal, and moored at Port Loy Isle of Cumbrae. It was later destroyed in a storm.

By the late 1960s, London University suffered from a lack of marine station facilities. Its existing small-scale facility at Whitstable in Kent was wholly inadequate for its needs at a time when the Heads of Zoology Departments in London University's Colleges were mostly marine biologists (Moore, 2009). London's biologists, in common with those of many other universities were finding difficulty in obtaining direct access to the kind of facilities they required by the sea. At the same time the increasing demand for marine material for research, teaching and examinations had generated acute shortages. The defined objectives of UMBSM then were to provide facilities for the study of marine biology, primarily, though not exclusively, for its two parent universities, together with other Scottish universities, and to provide supplies of marine biological material.

In 1968, a University Grants Committee (UGC) Working Party had been formed to investigate the matter. The University of London made its case and was offered the Millport Station, the greater part of which was then being vacated by the SMBA in its move to a new site at Dunstaffnage Bay, near Oban, chiefly to facilitate their emerging interest in deep-sea research, the need to be able to berth their new research ship, the RRS *Challenger* which arrived in 1973, and, according to C.M. Yonge (pers. comm. to PGM) the difficulty of recruiting high-quality younger technical staff to Millport due to it being on an island that, at the time, necessitated unpopular secondary schooling requiring weekly boarding in Rothesay on the adjacent island of Bute: because Millport was administratively part of Buteshire, not Ayrshire, the children had to go to Rothesay, rather than the much nearer Largs; this changed after local government re-organisation in 1975. Scientists, apparently, would always go anywhere! Yonge (1973) had referred to Millport as "a most unsuitable site for a research institute" and had lobbied for years for a move to Oban, although the fundamental reasons for this opinion were never made clear.

It was realised in Millport that the needs of other universities, especially those in Scotland and notably that of Glasgow, which had such a long history of involvement with SMBA, must be safeguarded and, as a result, the Universities of London and Glasgow entered into partnership to administer the Station in its new role. The partnership was never a 50:50 arrangement but more like 70:30, with London taking the lead role (Moore, 2009). As the University of London in those days had long-standing experience of administering far-flung college outposts overseas, e.g. in Africa and the Caribbean, a Scottish outpost was seen as no bureaucratic obstacle. Indeed, the first Director at UMBSM - Professor Norman Millott - had been Professor of Zoology in the University College of the West Indies, Jamaica, before returning to London's Bedford College. The staff at UMBSM were employed by the University of London but the academics taught Glasgow University students alongside London students at Millport and, in contributing teaching to the Zoology Department in Glasgow, were accorded Honorary Lecturer status in Glasgow. In addition to its educational

role, the station provided research opportunities for a wide range of Glasgow staff, notably zoologists such as Alan Taylor, Douglas Neil and Peter Meadows, botanists such as Don Boney and Trevor Norton, and microbiologists like Alastair Wardlaw and Harry Birkbeck. Postgraduate students based at Millport could register either with the University of London or Glasgow. A separate article in this volume provides details of marine science at the University of Glasgow (Meadows, 2024).

The Universities of London and Glasgow accepted financial responsibility for the Station from 1st June 1970 and full administrative responsibility with effect from 1st August 1970, with some of the older technical staff transferred from SMBA by 1st August. The University of Glasgow eventually, in reappraising its academic priorities but failing to exploit its unique freshwater and marine field station facilities, withdrew from UMBSM in 2011 and in the summer of 2013, the Field Studies Council (FSC) and the University of London reached a Memorandum of Understanding and the Millport facilities were finally transferred to FSC ownership. The University of London's withdrawal was associated with the fragmentation of the University as its colleges became independent universities. For a time, it appeared that the station would have to close altogether, but although this has not happened, the ending of Millport as a research facility is a serious blow to marine research in Scotland, as recognised by the international copepod expert David Damkaer who wrote of UMBSM "a nation's poor judgment closed it in October 2013" (Damkaer, 2017).

The earlier history of the Millport marine station is extensively covered by Kerr (1949) and in his *Gallery of Memories* (this volume).

Thanks to Jim Atkinson for finding some suitable illustrations in the archives.

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The Field Station: from ex-army huts to SCENE

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The University of Glasgow has operated a field research station on Loch Lomond continuously since 1946. The first field station was at Rossdhu on the western shore of the loch, immediately to the south of what is now the Loch Lomond Golf Club. The field station was established to build upon very successful courses in limnology offered by the Department of Zoology, initiated and taught by Harry Slack. These courses began in 1938 but were interrupted by World War II and only re-established in 1946. This field station was constructed from equipment surplus to the war effort and constructed at low cost on land within the grounds of Rossdhu House made available by Sir Iain Colquhoun, the laird of Luss Estates. The concept behind the field station was to provide a base from which field ecology research could be conducted and where students at all levels, from honours to PhD, could be given the opportunity to explore ecology in the natural environment. An early product - BSc (1959) and PhD (1963) - was Peter Maitland who progressed to a lectureship at Glasgow, then to the Nature Conservancy Council (1967) before embarking on his long career as a freshwater fish specialist. For many years this facility was the only one of its kind at a U.K. university.

Although the Rossdhu field station was a considerable success for students and staff in the Department of Zoology, the physical infrastructure, which comprised two ex-army huts, limited what could be achieved there. Thus, under the enthusiastic leadership of Harry Slack and with considerable support from C.M. Yonge, work began on establishing a purpose-built field station on the east side of Loch Lomond at Rowardennan, on land purchased from the then Forestry Commission. By 1963, construction work was underway and in 1964 the Glasgow University Field Station was officially opened. The purpose-built facility provided a field base, laboratory space to analyse samples and accommodation. The upper floor included two dormitories (capacity about 20), five single rooms, kitchen and shower/toilet facilities, and a multi-purpose room that served for lectures, meals and had space for a library. Downstairs was the teaching laboratory and two small research laboratories. According to Roger Tippett, Harry Slack had the slightly odd idea that students might wake in the middle of the night keen to examine specimens, so the dormitories were fitted with a laboratory bench and equipment! A separate building housed the Field Station's

Fig. 1. The Scottish Centre for Ecology and the Natural Environment (SCENE). (A) The entrance. (B) From above: SCENE in the foreground, the Dubh Lochan in the middle ground and Ben Lomond in the background. (Photos: SCENE)

caretaker/boatman/technician.

The first residential field course for Glasgow undergraduates took place in 1964, and began after the examinations in June. The single rooms were occupied by postgraduate students. One of the many attractions of this site was easy access to some of the finest habitat types in Scotland. Loch Lomond itself was made accessible by the construction of a boatshed in 1964 on the loch shore. Access to the oak woodlands on the Ross Peninsula, leased for teaching and scientific purposes from the Forestry Commission, and to the Dubh Lochan, a small glacial kettle lake immediately to the north of the new facility (both being designated as Sites of Special Scientific Interest and, later, Special Areas for Conservation) greatly enhanced the capacity for teaching and research there.

In the early 1970s, Stirling University negotiated an agreement to share use of the Field Station and provided funds to extend the capacity of the dormitories and laboratories to provide dormitory accommodation for around 30 students and a new larger teaching laboratory. To reflect the involvement of the two universities, the facility was rebranded as the University Field Station. For the next two decades, under the leadership of Roger Tippett, field courses from across Europe and beyond brought undergraduates to study ecology in the residential facilities there. PhD students and post-doctoral researchers worked on a very wide range of freshwater and terrestrial ecology topics ranging from aphid population dynamics to limnological processes. During this period, research funding was tight and Roger Tippett became adept at obtaining funds from sources such as the Manpower Services Commission for educational and environmental monitoring projects.

By the late 1990s the facilities had reached the end of their useful life and were in constant need of repair. In addition, Stirling University had withdrawn from the management of the site. A group of eminent scientists from industry, academia, government and the environmental charity sector was formed to consider the future of the field station. They concluded that there was a continuing and compelling need for a field station and the University of Glasgow senior management agreed. Thus, under the guidance of Professors Felicity Huntingford and David Green, began a programme of grant applications and a philanthropic fund-raising campaign to raise funding to replace and expand the facilities. In 2007, a new research building was completed at the site of the old University Field Station and seven years later, a new residential teaching facility was opened. This completed a £7.6 million redevelopment, creating the Scottish Centre for Ecology and the Natural Environment (SCENE) (Fig. 1). Both buildings were constructed to the highest levels of environmental sustainability that were reasonably possible. Both are heated with heat-pumps, have exceptionally high levels of thermal insulation and building materials and the construction process scored by an industry standard environmental assessment (Building Research Establishment Environmental Assessment Method) as "Excellent". In recognition of this the first building to be constructed won the 2008 Carbon Trust Low Carbon Building Award.

SCENE currently supports around 20 research projects and 27 researchers, and around 3,500 student-nights are spent in the facilities by visiting groups who come to learn more about ecology, the environment and how both are managed, by immersing themselves in some of the most important ecosystems that Scotland has to offer.

Thanks to Roger Tippett and Walter Edgar for recollections of the earlier days of the Field Station.

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Keeping the ship afloat: the changing roles of technical and ancillary staff

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INTRODUCTION

John Graham Kerr (JGK) makes no mention of technical and ancillary staff in his *Gallery of Memories* (this volume), but Agnes Miller in her article on the early days (also this volume) gives a vivid account of two members of the technical staff: J. Brannigan, employed 1902-28 and P. Jamieson, in post over the same period. These two therefore started with JGK's arrival, but retired a few years after the move to the new building (1923). Brannigan ran the teaching laboratory and acted as a buffer between JGK and the students. Jamieson ran the histological laboratory, crucial to the department's research. Here we give an account over the last 50 years or so of the technical and ancillary staff who provide the foundation that allows academic staff and students to do their work. It is worth noting here that the contributions technical staff make to research can be more than simply "support", allowing them to be included as co-authors of the published work.

TECHNICAL STAFF

Training

During the 1960-1980s, most technical staff joined the University as apprentices soon after leaving school. June Freel, who started in 1985, has given us a description of her duties and pattern of work:

- Sign in and out every working day, 8.30 a.m. to 4.30 p.m. Late arrival or early departure would result in a stern talking to from the Chief Technician, Mr Anderson (whose first name, Peter, was unknown and certainly not used by other technicians).
- Attend college every Wednesday to study towards a Higher National Diploma in Biological Sciences. This was a great opportunity for June, who came from a family with no history of higher education.
- Attend each year a six-week summer school: trainees rotated through different laboratories, a week in each, learning new skills and techniques, such as photography, electron microscopy, histology, and fieldwork methods. The school ended with an examination and a report on performance and aptitude. June recalls never being asked back to help with electron microscopy!
- Trainees were mentored by a senior member of the technical staff: in June's case, this was Cathy McLagan, Senior Technician in the Physiological Laboratory. Cathy could reduce June to tears on occasion, but was also a great support and an excellent teacher of key skills.

June helped Cathy run the laboratory, and by 2003 had risen to be Deputy Chief Technician, then Chief in 2004, sadly leaving in 2005 when her family moved south. Margaret Mullin's career path (see Mullin *et al.*, 2024) was similar to June's except that she was invited back to electron microscopy, and is still there! The college/apprenticeship route to an established technical post is now uncommon. Technicians are now more often appointed to grant-aided (and, therefore, time-limited) posts, and are often graduates.

Teaching laboratories

Into the 1980s, the Zoology building had five undergraduate teaching laboratories: the large ground floor laboratory with its preparation room, originally designed for medical students; two smaller ground floor laboratories for advanced students; and two upstairs laboratories used for Level 3 classes. By the late 1990s, all except the large ground floor laboratory had been converted into research laboratories and offices, with many undergraduate classes moved to the Boyd Orr Building. The teaching laboratories were serviced by a team of technicians and laboratory assistants. For many years, the team was led by Liz Denton and her deputy Dave Barnett, helped by Isabel Thompson, Lily Dornan, Irene Leighton and Alister Kirk (Fig. 1). There was a lot to do, since the Zoology courses included a major component of often complex practical work: microscopy, histology, dissections, physiological and behavioural experiments, and museum specimen demonstrations, with chemicals to prepare, apparatus to lay out, test and maintain, then clear away and clean ready for the next set of work. When Liz Denton retired, Pat McLaughlin took over, later replaced by Margaret Packer, who has had the task of overseeing a major laboratory refurbishment (completed in June 2024).

Fig. 1. A group of technical staff enjoying Lily Dornan's retirement event. From the left: Anne Keenan, Cathy McLagan, Pat McLaughlin, Lily Dornan, Isabel Thompson, Liz Denton and Maureen Gardner. (Photo: K. Griffiths)

Outside the teaching terms, once any cleaning and equipment maintenance was completed, teaching technical staff could be deployed into research areas. Liz Denton had an additional role as graphics guru: she

curated the Department's stock of Letraset, used to label photographs and to create diagrams and graphical figures in pre-word processor days. She developed graphics skills still employed by academic staff after her retirement.

Animal services

In the 1970s, the basement housed an insect room, marine aquaria, a *Xenopus* frog and axolotl room, and rooms for Tony Barnett's rats and mice, some of the space being for his cold temperature adaptation research. Over the next few decades, the animal-holding facilities were in constant flux as research programmes came and went.

For many years, the animal services technical team was led by Raymond Stoddart, later by John Laurie (who went on to become Chief Technician) and then by Graham Law. Graham had been an innovative keeper of carnivores at Glasgow Zoo and brought valuable expertise which was incorporated into the Masters course in Animal Welfare Science, Ethics and Law (AWSEL), until his untimely early death from cancer in 2020. As a memorial, the AWSEL course includes the Graham Law Enrichment Challenge (6th iteration in 2024), where students work in small groups during the final session of the course at SCENE to devise a way of enriching the lives of members of a species identified as having welfare problems when kept in captivity. Graham's role as animal services manager in the GKB was taken by Ross Phillips. Animal services staff are now managed by a separate department, Biological Services.

Histology

Histology had been a crucial technique for the zoologists of JGK's time who were interested in comparative anatomy, physiology and embryological development. In the 1970s, the parquet-floored histology laboratory (Fig. 2) was located up a short stair at the north end of the Museum and was run by a highly-talented histologist, Cathie Morrison. When the Developmental Biology unit was opened at Horselethill in the early 1970s, Cathie moved to be Technician in Charge and she was replaced in Zoology by Pauline Hannah. The laboratory was demolished along with the entomology wing below in the 1990s, and replaced by the new Central Research Facility, below, with office and lab space, above. Kate Orr (later Griffiths) was now Histology Technician, recruited from the health service, looking after the histology slide collection, helping with PhD and undergraduate student projects and undergraduate histology practical classes. Histology moved to the new bespoke histology laboratory in the roof facility created to replace that lost to the fire. In the late 1990s, histology moved along the roof laboratory corridor, to make way for a molecular laboratory (see Mable *et al.*, 2024). Kate spent half of her time working in histology and half of her time in the new molecular laboratory. Histology was now playing a less important role in Zoology teaching and research. As part of the rationalisations accompanying the formation of the Institute of Biomedical and Life Sciences (IBLS), histology facilities were eventually centralised in the Anatomy Department, and Kate's responsibilities changed.

Fig. 2. The original histology laboratory in 1990. (Photo: K. Griffiths)

Photography

Photography has long been an important means for zoologists to record their observations. JGK was a keen and expert photographer and has left a substantial archive of plates and prints. For several decades, the basement housed a photographic suite with darkroom and developing/printing facilities. From 1961 until his retirement, the departmental photographer was Peter Rickus. Photography and other imaging activities were centralised by IBLS and the photographic suite space redeployed. The wide availability of digital photography has revolutionised how zoologists record their findings.

Molecular ecology

As described in Mable *et al.* (2024), by the mid-1990s, molecular techniques including DNA sequencing were becoming an affordable tool for use in zoological research. A molecular laboratory was set up in the refurbished roof facility by Richard Griffiths in 1996, by conversion of the histology and parasitology laboratories, aided by Bob Dawson whom Richard had met on a beach in Norfolk, where both were birdwatching. Richard remarked that he was seeking a good post-doc and Bob was looking for a job: thus began a long-term working relationship and friendship. After histology facilities had moved to the Anatomy Department, Kate worked full time providing technical services for the new molecular laboratory. The

molecular laboratory initially supplied a service for bird conservation and research work, an example being sex identification of chicks during the re-introduction of red kites and white-tailed eagles to Scotland. In 2007, a "pop-up" set of molecular laboratories was introduced to our Walney fieldwork site. This enabled identification of lesser black-backed gull (*Larus fuscus*) chick sex from DNA extracted from tiny blood samples taken on the same day.

Physiological laboratories

The physiological laboratory on the roof provided facilities for the mainly marine-based research carried out by J.D. Robertson, Peter Spencer-Davies and Alan Taylor. Cathy McLagan was Technician in Charge for many years, assisted by June Freel latterly. The electrophysiology laboratory was originally in the yard, but moved to a better space created by cutting a thick slice off the Museum in the 1960s. The Technician in Charge was Don Little, with special expertise provided by Don McFarlane as Research Technologist. Graham (Toby) Tobasnick was Junior Technician there but also helped with parasitological research and moved fully to that area later. Graham Adam also assisted in this field both for teaching and research.

Fieldwork and field station

Fieldwork carried out by Zoology researchers has been supported by several members of the technical staff, much of it remote from Glasgow and sometimes involving remote residence. Pat McLaughlin assisted with Peter Meadows' Clyde estuary work, carrying back many buckets of sediment. Kenny Ensor, Darren Evans and Kate Griffiths have helped ornithological fieldwork in several ways and at many locations, such as Walney Island, Ailsa Craig, Bass Rock and Foula. The Rowardennan Field Station (now SCENE) combines being a residential location for field-courses with being a centre for freshwater and terrestrial field and laboratory research. This requires technical and ancillary support that is complex and demanding. For many years, the residential facility was managed by Rona Brennan who developed a deserved reputation for catering excellence. During the fund-raising campaign for the new buildings in the early 2000s, Rona wrote a recipe book - *The Soup SCENE* (Fig. 3) - which sold well. The original Rowardennan field station included a cottage for a caretaker/boatman/handyman. Joe Twaddle was the original incumbent, later replaced for many years by Rab McMath. The cottage was demolished to make way for the SCENE buildings. Hannele Honkanen is now Research Support Manager, assisted by research Technician Phoebe Kaiser-Wilks.

Stores

The basement housed the departmental stores of chemicals, glassware, stationery and all sorts of other useful items. From 1965, the genial storekeeper was Mr Flett who had an amazing memory of the range of items he stocked. He was latterly assisted by Willie Orr. When IBLS formed, Zoology stores were consolidated into the Davidson Building and Willie had to move there: stores were never the same after that.

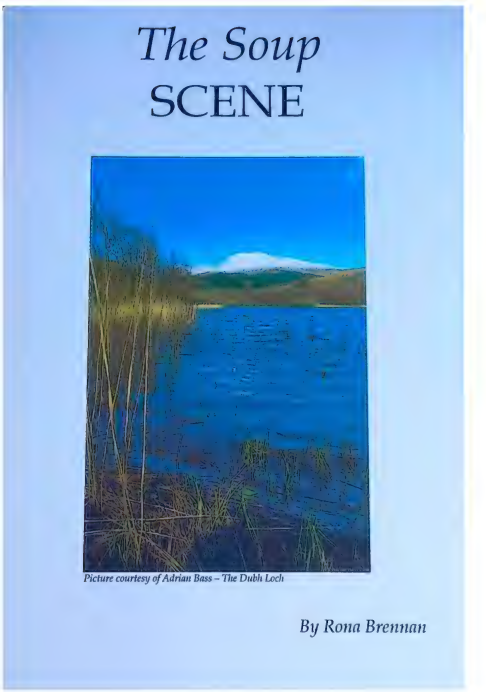

Fig. 3. Cover of *The Soup SCENE*. (Photo: L. Kennedy)

Workshops and Electron Microscope Unit

The basement also housed two workshops. The Mechanical Workshop was presided over for several decades by Alan McGregor (Fig. 4) who seemed able to construct anything zoological researchers needed out of metal, wood, glass and Perspex. This workshop later moved to the West Medical Building as part of the IBLS streamlining process. The activities and staff of the Bioelectronic Workshop and of the Electron Microscope Unit are described in Mullin *et al.* (2024).

Fig. 4. A mid-1990s celebration in the Museum. From the left: Nosrat Mirzai, John Laurie, Alan McGregor and Martin Burns. (Photo: K. Griffiths)

SECRETARIAL AND ADMINISTRATIVE STAFF

When Roger Downie joined the academic staff in 1970,

those staff were supported by a team of secretaries: Mary McDill was Senior Secretary, working for the Head of Department; she was assisted by Clarice Swann and Theresa Emerson, with Susan Hughes working in the basement primarily on accounts. It was the norm then for academic staff to have their hand-written notes (for teaching or research documents) typed up by the secretaries, or even for the secretaries to take short-hand by dictation. Clarice was very short-sighted, but had an eagle-eye for poor grammar and could be very firm on the standard of writing she expected from academics. Lecture and laboratory hand-outs were typed onto Roneo machine stencils from which many copies could be run off in black and white. Clarice stored the stencils and these could have minor revisions made and used in subsequent years. For coloured diagrams, a Banda copier was available. The outstations had their own secretarial staff.

The information technology revolution of the 1980s progressively swept all this away. Photocopying became cheap and replaced the Roneo machines. Word-processing made it easier for even slow typers among the academic staff to produce their own manuscripts. The changes in departmental structures centralised some services: for example, Susan Hughes's successor Brenda McPherson began in the Zoology basement, moved to the West Medical Building when IBLS formed, and ended up in the Medical School as part of the College's accounts team.

The roles of departmental secretaries have changed and expanded. For example, Lorna Kennedy, who joined in 2000, now has two main roles: first, Personal Assistant to the School's Director of Research, with tasks such as diary management, meetings arrangement, and travel organisation; second, Local Resource Coordinator, which involves managing the processes and procedures relating to staff recruitment. Those are her official duties, but, as Dan Haydon (Director of the Institute of Biodiversity, Animal Health & Comparative Medicine – IBAHCM - for 12 years) has commented, she is also "fixer of all things", a role not easily defined in standard job descriptions. Her pattern of working has also been altered as a result of the COVID-19 pandemic; she now works in hybrid format, partly from home and partly from the office. Lorna succeeded Irene McLaren as Principal Secretary, and initially had Patricia Johnson and Florence McGarrity as assistants, now succeeded by Nathan Miller and Kotryna Ula Kiliulyte.

As part of the College/School structure, there are now administrative staff in charge of particular functions, mostly not based in the Graham Kerr Building. The Undergraduate School manages the major task of administering all the undergraduate courses; the Graduate School administers post-graduates, with separate staff for research students and taught Masters courses. Research and research assessment are administered by a separate team. Building maintenance and development involves liaison with the University's Estates department and this is handled by Chief Technician Kate Griffiths and a senior administrator, Deputy Head of Professional Services, Jennifer Crawford.

JGK makes clear in *Gallery of Memories* that he regarded public engagement as an important part of his role, and this remains important for any university these days. It is worth mentioning two Zoology graduates with key roles in this area, although neither is based in the Graham Kerr Building: Debbie McNeill manages the annual Glasgow Science Festival each June, and is also engagement manager for the College; and Zara Gladman is Public and Community Engagement Manager for the University's Research Services department.

ANCILLARY STAFF

A building like the GKB houses a large number of staff, but also has a shifting population of students attending lectures and laboratory classes, and also hosts occasional visitors like the general public visiting the museum. This all creates a need for cleaners, reception staff and others. As the independent Department of Zoology, we generally had a regular team of cleaners who got to know the building and its inhabitants well, and who often worked many years (Fig. 5). The same was true of the janitors who staffed the reception office in the building's foyer. On some occasions, we had "janitors" who performed multiple functions such as driving the minibus and carrying out handyman duties. This included David Boyd who went on to be Head of Janitorial Services for the University, and Davie Watson, happy to transport students and staff to many diverse and unusual destinations, often outside of the Glasgow area. Unfortunately, the University centrally took against having ancillary staff assigned long-term to particular buildings, and these personal links have been largely lost, although we have enjoyed the extended deployment of Mark Johnstone and Stephen Monaghan to the building.

Fig. 5. Retirement event for cleaner Margaret Moyers (Mags) who worked in the Graham Kerr building for 17 years. She is seen here behind a hamper of gifts, with a good turn-out of staff in the Museum, August 2022. (Photo: N. Metcalfe)

CONCLUSION

There have been some bumpy times for technical and administrative staff. Possibilities for promotion are very rare and are hard won. However, the help and support

provided by some excellent Heads of Department, including Felicity Huntingford, Roger Downie, Neil Metcalfe and Dan Haydon have largely smoothed over the cracks. During the period when Zoology was principally contained within one building, there was a strong feeling of congeniality and many opportunities to participate in social events. Weekly seminars were of general interest to all research groups within the building, and all members of staff were encouraged to attend. There were annual summer post examination barbecues for students and staff, and an end of session Christmas lecture and ceilidh. Technical and support staff are unlikely to become extinct as a species, and hopefully the University of Glasgow will continue to recognise the much-needed contributions to research and teaching provided by these staff members.

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Developing role of teaching staff in Zoology at the University of Glasgow

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Prior to 1970, undergraduate numbers in Zoology at the University of Glasgow were typically low and teaching was managed by academic staff. However, widening access to universities throughout the 1970s brought an increase in student numbers in Zoology and resulted in the recruitment of postgraduate students to assist with undergraduate teaching. Postgraduates were typically employed as laboratory demonstrators. Duties involved assistance with laboratory teaching and marking laboratory reports, some examination questions and essays. Demonstrators were paid an hourly rate with no contract.

Student numbers continued to increase throughout the 1980s alongside changes in university staffing. The introduction of the Research Assessment Exercise (RAE) put academic staff under increasing pressure. The role of postgraduate students broadened to include Level 3 tutorial groups, some lectures, assistance with honours projects and setting examination questions. In addition, with the introduction of computers in teaching, funding was becoming available for short-term contracts for teaching-only staff to develop and assess, with the University's Teaching and Learning Service (TLS), new technologies to aid in student education. The development and assessment of computer-assisted learning (CAL) was an exciting time in university teaching. Some teaching staff were employed on part-time, short-term contracts to develop new CAL programs for student courses. These programs were assessed in-house and by the University's TLS, thus giving an academic approach to changes in teaching practice. A number of Zoology teachers were also involved in trials of Problem Based Learning (PBL) sessions for Parasitology students, before PBL was used in Medical teaching.

The Institute of Biomedical and Life Sciences (IBLS) formed in the mid-nineties. From 1994, teaching staff were employed by the IBLS Undergraduate Teaching Unit (UTU) as Teaching Assistants (TAs), but the title was soon changed to Associate Lecturers (ALs), as this was deemed a more appropriate reflection of their duties, qualifications (most had PhDs) and their contributions to teaching and the development of teaching. Associate Lecturers were employed on a yearly basis and on 75% of the salary scale for research and analogous staff. However, in Zoology, field-courses and summer project work involved working all year round. The duties of TAs/ALs involved the organisation and delivery of teaching, examinations and administration of courses. They were employed to strengthen teaching in Zoology (and later across IBLS) whilst enabling other members of staff to concentrate on research, with the aim that the units within IBLS should sustain their excellent position in future RAEs.

Primarily, Associate Lecturers in Zoology were assigned to support and contribute to the educational provision based in the Division of Environmental and Evolutionary Biology (DEEB), including all forms of teaching, examining and assessment. ALs were expected to contribute to student support as Advisers of Studies (often with loads of more than 100 students) and to participate in collaborations between the Undergraduate Teaching Unit and the University's Teaching and Learning Service (some ALs had prior experience in the development and assessment of computer-assisted learning projects in association with the University's TLS). ALs were also expected to train as Facilitators and participate in the Problem Based Learning Programme on which the new Medical Curriculum was based.

Initially, two Associate Lecturers were assigned to DEEB. Most ALs employed across IBLS were women. However, in DEEB from 1999-2014, the gender balance was 50/50. The temporary nature of their contracts was

generally seen as a problem by ALs. Renewal of the nine-month contracts was often delayed and this made job planning difficult and caused much anxiety. Associate Lecturers were also expected to maintain a research profile.

In 2003, the title of Associate Lecturer reverted to Faculty Teaching Assistant (FTAs), seen by some as a retrograde step, and ALs had to reapply for their own posts. There were several issues with this, especially as a number of ALs/FTAs were performing senior roles in their respective units, as Course Coordinators and Examination Officers, and in contributing to curriculum development and to educational and subject based research. However, in 2004 a number of FTAs successfully applied for the new post of University Teacher (UT), but were then placed on a two-year probation, following which, in 2006, a few successfully applied for the post of Senior University Teacher. It was now considered that a career structure had been put in place that reflected the significant contribution University Teachers made to the high standing of Zoology (and Marine and Freshwater Biology) degrees in both the National Student Survey (NSS) and in the Teaching Quality Assessment (TQA).

University Teachers have made a valuable contribution to the education of Zoology and Marine and Freshwater Biology students over the years. Their role as Course Coordinators and Examination Officers for DEEB degrees has been crucial in reviewing the effectiveness of teaching and in keeping in touch with the academic needs of students, including responding to student feedback, thus keeping our courses fresh and academically excellent. New courses have been introduced and continue to be developed to meet changing needs. The pastoral duties of University Teachers (often overlooked by other staff) have also been important in ensuring students are supported to achieve their academic potential and enjoy their educational experience. Some of this development work has resulted in publications in the biological education field. These may report on a case that others could take advantage of (Coombs *et al.,* 2013), or a practice innovation in a general area like graduate employability (Zainuddin *et al.,* 2022), or on procedures that help the development of staff expertise (Bailey *et al.,* 2022), to give just a few examples.

In 2010, a dramatic shift in University structure resulted in a number of voluntary staff redundancies in DEEB. Much of the teaching carried out by these long-term staff was picked up by University Teachers. In 2011, we employed a further UT (Dr. Le Vin) and in 2012 Drs. MacGregor, Bellingham and Paterson. In 2012, with the departure of Professor Ruxton, Dr. Coombs took on the role of Head of Subject for Animal Biology (Zoology and Marine and Freshwater Biology degrees), steering our degrees through the developments needed to keep up with the major changes in structure.

After the retirement of Dr. Coombs in 2014, Dr. Lindstrom took over as Head of Subject for Animal Biology with Dr. Spatharis as his Deputy. In 2017, the post of University Teacher was renamed University Lecturer and promotion to Senior University Lecturer, Reader or Professor became possible. Dedicated career tracks were established, namely Learning, Teaching and Scholarship (LTS) and Research and Teaching (R&T) with LTS staff expected to carry out pedagogical research.

The Graham Kerr building (GKB) has been a home from home for our undergraduate students for many years, with a large proportion of teaching taking place in the GKB and students using the Zoology Museum and the Computer Cluster as a base to study and meet their peers. Dedicated social rooms for undergraduate students were also available in the past. However, as student numbers, including postgraduates, continued to grow, and staffing increased in the Research and Teaching track, less space was available to use as social and study space and much of our undergraduate teaching now takes place across campus, resulting in a possible loss of community. A redeeming feature, however, is our field courses in Year 3 where students start the year at our custom-built Scottish Centre for Ecology and the Natural Environment (SCENE) at Loch Lomond. Our field courses help to build a sense of community among our students as they make friendship groups that can last a life-time, and many find a sense of belonging among their peers. That, and the fact that most of our laboratory teaching continues to take place in the GKB, help to maintain a great student experience.

The COVID pandemic in 2020 brought a multitude of challenges for teaching staff and students alike. The swift switch to home working and online learning involved a steep learning curve for all involved. However, it has brought positives in creating additional online teaching resources to back up in-person teaching as well as allowing students with disability needs, or even short-term illness, to use these resources to support or catch up with learning. In Zoology, all teaching has returned to face-to-face and thus the student experience has been maintained. The benefits of working from home for staff have also been embraced, where possible, thus contributing to the maintenance of a good work/life balance.

As discussed, there have been sweeping changes in University structure and workforce in the last 25-30 years (not least the recent change in 2022 with Animal Biology being incorporated into the School of Biodiversity, One Health and Veterinary Medicine (SBOHVM)), with an increase in teaching-focused and administrative staff to free up academic time for research. Initially, changes were at a pace where the effect on quality of student education could be monitored but, more recently, a lack of formal analysis could be seen as a retrograde step. However, despite this, Zoology has consistently been rated in the high 90s in the National Student Survey. Pleasingly, 2023 saw the University of Glasgow Zoology degree rated the highest for student satisfaction in the U.K., which would indicate that, for Animal Biology, the current balance is

working.

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Microscopy, bioelectronics and other innovations in the flourishing of Glasgow zoology

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As recounted in *Gallery of Memories* (this volume), John Graham Kerr (JGK) arrived in 1902 in a department lacking any kind of scientific equipment. He quickly moved to put in place the essentials of the time: good quality microscopes for teaching and research, and the staff and facilities needed to prepare specimens for examination. A histology preparation room with skilled staff remained part of the Zoology building until the late 1990s. Here, we outline a few of the areas where technical innovations have transformed zoology research and teaching over the last century.

ELECTRON MICROSCOPY

The light microscope had reached the limits of its powers of resolution through the efforts of Abbe and Zeiss in the late 19th century, but biologists were keenly aware that there existed biological structures that they could not distinguish even with the best light microscopy. JGK's lecture notes from 1917 (this volume) give an example: transmissible diseases, but no visualisable organisms. This frustration was alleviated by the invention of the transmission electron microscope, available to biologists after World War 2, and led to the visualisation of viruses and the structures inside cells such as mitochondria and endoplasmic reticulum. In Glasgow Zoology, funding of £14,600 from the Department of Scientific and Industrial Research in 1964 allowed the purchase and installation of an AEI EM6 transmission electron microscope (Anon, 1965) in a basement facility designed by Gareth Owen and Hugh Steedman, both of whom moved elsewhere that year. Jim Cowey was put in charge of the new facility, with Maureen McCallum (later Gardner) as technician. Cowey and Bob Clark (who later moved to Bristol) had published a study on shape-changing in soft-bodied invertebrates (Clark & Cowey, 1958), later regarded as highly influential (Shandwick, 2008). Ultrastructural analysis of parasitic protozoans was a major focus of Keith Vickerman and his group's research from 1968, and this was greatly facilitated by the appointment in 1974 of Laurence Tetley (Fig.1) as research technologist, tasked with managing the Electron Microscope Unit (EMU). In 1978, the University appointed Margaret Mullin straight from school as a trainee technician. Her main duties were to service the biology and medical teaching laboratories in the Boyd Orr Building, but in the summer vacation, she worked in the EMU, learning how to use all the equipment. Several of the biological science departments had their own electron microscopes, but the re-organisation that led to the formation of the Institute of Biomedical and Life Sciences (IBLS) led to a consolidation of facilities and, in 1989, a combined EMU was located in the Chemistry (Joseph Black) Building: by then, Maureen had become the trade union representative for all University technicians, and Margaret was full-time in the EMU, a post she still occupies happily (Fig. 2), after 46 years in the university! The Unit's facilities have changed and expanded several times over the years: scanning, as well as transmission, electron microscopy; most recently, cryo-transmission allowing the examination of frozen specimens, and a new Jeol 1400 Flash TEM in 2023. This scale of investment shows the continuing importance of ultramicroscopy to many aspects of the biological sciences: for zoology, much of this work has been in parasitology, but there are few aspects where microscopy has not been important.

Fig. 1. Laurence Tetley at work at the Zeiss transmission electron microscope, 1980s. (Photo: EMU archives)

Fig. 2. Margaret Mullin in the EMU preparation room, 1980s. (Photo: EMU archives)

BIOELECTRONICS UNIT

Comparative and neurophysiological research in zoology both require the development and construction of complex specialist instruments, often not obtainable from commercial sources. This need led in the 1960s to the establishment of a bioelectronics unit, located in the GKB basement, and still there. Don McFarlane was the research technologist in the early days, but Martin Burns, employed as a lecturer, became more and more interested in instrument design using microelectronics, and their deployment for new purposes. For example, he designed a weighing device disguised as a rock which could monitor the weights of wild birds non-invasively. With the formation of IBLS, the Bioelectronics Unit expanded to work for the whole Institute, and for over 30 years Nosrat Mirzai was one of its staff, first under Jim Sinclair, then as its principal: he retired officially in 2020, but remains active. Jakub Czyzewski has taken over as leader of the team.

The Unit works closely with all sorts of biomedical and biological researchers to develop new solutions to problems, delivering cutting-edge innovations that enable research on otherwise intractable and unaffordable topics. For example, the Unit has designed mosquito electrocuting traps (MET) used by Heather Ferguson's team to measure the behaviour of mosquitoes feeding on people (Fig. 3), and vital for the design of vector control strategies against malaria, yellow fever, Zika virus and others. Another major collaboration has been with the researchers studying bird and mammal migrations: the design of Radio Frequency Identification (RFID) devices that can be painlessly attached to wild animals has allowed unprecedentedly accurate information to be gathered on individual animal behaviour. Yet another device has allowed the measurement of the bite force generated by fish, providing insights into the adaptations that allow different species to utilise a range of food sources such as corals. Another example to demonstrate diversity is the device designed to measure spore dispersal by lichens during Sally Eaton's research on epiphytic plants of the Scottish temperate rainforests (Fig. 4).

A recent acquisition is the Unit's 3D printer. For the Baltic Seabird Project's auk laboratory's evaluation of

Fig. 3. MET in use in Tanzania, *ca.* 2020. (Photo: Bioelectronics Unit)

Fig. 4. Automated spore collector in use on a Glasgow street, *ca.* 2020. (Photo: Bioelectronics Unit)

heat dissipation in breeding common guillemots, local microclimate measurements were needed. To obtain accurate air temperature data, the thermocouples used had to be housed in a radiation screen specific to the breeding ledge used by the birds. No commercially available screen could be sourced, but the 3D printer did the job (Fig. 5).

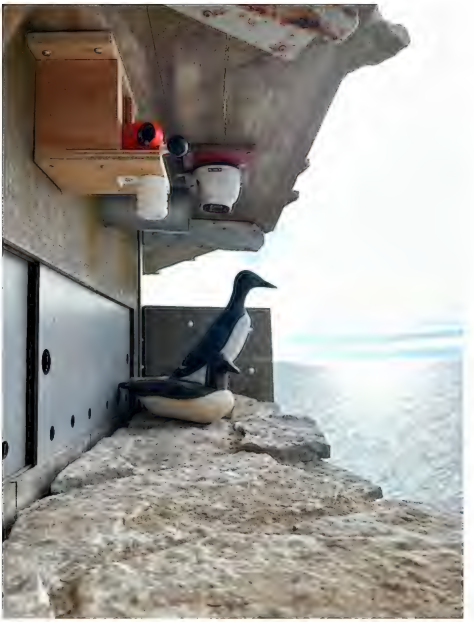

Fig. 5. The 3D printed radiation screen: white cylinder attached to the wooden box. Two dummy guillemots on the ledge. (Photo: David Stone)

OTHER INNOVATIONS

Several other innovations have revolutionised the practice of zoological research over the last century. Mable (2024) describes the most recent: the ability to sequence DNA and its impact on evolutionary and ecological studies. Another obvious example is the pervasive influence of information technology. Modern computers allow the compilation of enormous databases which can then be interrogated by more and more sophisticated statistical methods. Computers also enable the construction of complex mathematical models which can help us understand trends like the impacts of climate change on biodiversity. These developments have meant that the appointment to zoology of staff members whose expertise is primarily mathematical, computational or statistical is now entirely normal. The results of some of their efforts are described in Monaghan (2024).

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One Health: expanding the frontiers of zoology

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The study of parasites and infectious diseases at the University of Glasgow has a rich history that is closely intertwined with that of Zoology and the Zoology building. Early examples of major scientific contributions linked to the department include the discovery of Zika virus by Alexander J. Haddow, a Glasgow Zoology graduate who later became a Professor and Dean of the Faculty of Medicine in the University, and the pioneering work on sleeping sickness and antigenic variation by Keith Vickerman, who was Head of Department and Regius Chair of Zoology (see other articles in this volume). Just as the study of Zoology requires consideration of environment and ecology (as reflected in various incarnations of the zoological community in the Graham Kerr building: the Division of Environmental and Evolutionary Biology, and then of Ecology and Evolutionary Biology), it became natural to combine our strengths in pathogen biology and evolutionary ecology to include infectious disease ecology. The creation of the College of Medical, Veterinary Sciences and the formation of the Institute of Biodiversity, Animal Health and Comparative Medicine (IBAHCM) in 2010, under the leadership of Professor Dan Haydon, marked the start of the latest chapter in this long history linking zoology and infectious disease at Glasgow.

Infectious disease ecology was already something of a poster-child for the increasing expectation of funders that research should become more interdisciplinary, benefitting as it does from the inputs of so many other disciplines including molecular biology, mathematical and statistical modelling, and social science. But by bringing together researchers from ecological, evolutionary and veterinary backgrounds, IBAHCM also reflected an increasing realisation that the health of

human and animal populations, whether free-living or domestic, as well as that of the ecosystems supporting them, are intimately linked and interdependent. This concept, commonly referred to as One Health, became more widely recognised in the early 2000s and has risen to increasing prominence since, not least due to its relevance for addressing the threat of emerging infectious diseases, as highlighted by recent global pandemics caused by influenza, HIV, and SARS-Cov2. Central to the One Health paradigm is not only an emphasis on humans and other animals sharing pathogens and other factors impacting their health, but also the acknowledgement that solutions to these problems require the collaboration and integration of disciplines, including those of the veterinary and medical professions. The existence of a highly regarded School of Veterinary Medicine within the University created a unique opportunity to achieve such disciplinary integration when IBAHCM was formed. Fully merging the Institute and the Veterinary School in 2022 to form the School of Biodiversity, One Health and Veterinary Medicine, was a logical progression on this trajectory and resulted in a department with even greater critical mass to address global environmental and health challenges in a holistic way.

The importance of a One Health approach is exemplified by rabies, a viral zoonotic disease for which our department has produced world-leading research over the past two decades. Rabies virus is maintained in animal reservoir populations, most commonly domestic dogs, so its surveillance and control had been traditionally regarded as a veterinary problem. This has made it difficult to address rabies as a public health issue, despite infections, if left untreated, being invariably fatal and continuing to cause about 60,000 human deaths each year. Research led by Glasgow scientists has demonstrated the crucial role of domestic dogs as the main animal reservoir and the feasibility of canine rabies control and elimination through mass dog vaccination. Importantly, these research findings were crucial for driving major policy change and strategy within global governing bodies, including the World Health Organisation (WHO). In settings where wildlife acts as a major rabies reservoir, such as vampire bats in South America, research within the department has led to the pursuit and evaluation of novel control strategies, including the intriguing possibility of transmissible vaccines.

For most zoonotic diseases, the burdens fall predominantly on communities within the global south. Building long-term and equitable partnerships with institutions and governmental agencies in those countries most affected, has therefore been a hallmark of One Health research at Glasgow. Connections have been particularly strong in East Africa, especially Tanzania, where research has focused on diverse challenges including the control of human malaria and schistosomiasis, antimicrobial resistance, human-wildlife conflicts, and livestock health. The latter is another poignant example of the interdependencies lying at the heart of One Health, given that the livelihoods of communities in the global south often critically rely on livestock as a source of food and income. At the same time, the land inhabited and used by livestock-owning communities can also support biodiverse ecosystems, creating opportunities for pathogens to cross species boundaries and resulting in complex transmission patterns involving wildlife, domestic animals and people. Many of our scientists have been working in these settings for much of their careers and the research emanating from this has become a major part of what the department is now internationally known and recognised for. Long-lasting collaborations across sub-Saharan Africa, such as with the Ifakara Health Institute in Tanzania, have also resulted in a consistent flow of visiting students, postdocs and staff to the department over the years, and thus have shaped the international research network it is embedded in.

Addressing One Health challenges such as anti-microbial resistance or disease emergence often requires solutions that combine biological, medical, environmental, economic and social components. This has forced Glasgow researchers to forge highly interdisciplinary teams, either by recruiting staff members with relevant expertise into the department or by finding this expertise elsewhere. The former of these two approaches has led to the novel appointment of staff coming from non-biological backgrounds, including mathematics, computer science or economics. The second approach has resulted in strong links over the years to other Schools and Colleges within the University, including Mathematics and Statistics and Social and Political Sciences. These links were formalised through the creation of the Boyd Orr Centre for Population and Ecosystem Health, a virtual grouping founded in 2008 and named after Sir John Boyd Orr, a University of Glasgow graduate (and student of John Graham Kerr) who was awarded the Nobel Peace Prize in 1949 for his work on human nutrition and leadership as the first Director of the United Nations Food and Agriculture Organization (FAO). Inspired by Boyd Orr's vision of science that delivers real world impact by improving people's health and wellbeing, the Centre emphasises approaches that are both pragmatic and quantitatively rigorous. For its innovative contributions to improving human and animal health, the Boyd Orr Centre was awarded the Queens Anniversary Prize in 2013 (Fig.1).

In addition to parasites and infectious disease, the One Health concept also highlights the value of a comparative approach to animal and human health. Many of the issues affecting the latter, such as ageing, epigenetic effects, and cancer, can be studied in a wide range of animal models, including wild and domestic species. Over the past twenty years, research within the Institute/School has very productively pursued this angle to One Health to answer, for example, the question why some individuals age faster than others or whether even after exposure to environmental pollutants has stopped, the health of future generations may be affected by epigenetic effects.

Fig. 1. Members of the Boyd Orr Centre for Population and Ecosystem Health visiting Buckingham Palace in February 2014 to attend the Queen's Anniversary Prize ceremony. From left to right: Joaquin Prada, Dan Haydon, Caroline Millins, Minnie Parmiter, Barbara Mable, Richard Reeve, Rowland Kao, Sarah Cleaveland, Richard Orton, Sunny Townsend, Tiziana Lembo and Louise Matthews. (Photo: Rowland Kao)

The academic merits of extending and connecting broadly zoological ideas into so many interdisciplinary spaces has not gone undebated. It has, however, broadened and diversified our research funding base and led to a significant expansion of our staffing numbers; it has enriched the societal impact of our research, contributed to a rich academic environment that has attracted research fellows from far and wide, and placed our research community increasingly towards the centre of College affairs.

Attracting researchers studying the ecology and evolution of infectious disease and One Health has also had a profound effect on our teaching. Since 2013, we have been offering a popular Level 4 course on Disease Ecology as part of the Zoology and Marine and Freshwater degree programmes. At the postgraduate level, we have introduced multiple Masters degrees, providing training and skills in areas such as in quantitative epidemiology, infectious disease modelling, and anti-microbial resistance. The case of One Health shows how zoology as a field continues to find new applications and relevance in the context of other disciplines. Seeing zoology becoming embedded in the broader, more diverse research teams that characterise One Health, highlights its essential contribution to tackling some of the most pressing research problems of our times.

I thank Dan Haydon for useful comments and suggestions.

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St Andrew's Clinics for Children (STACC)

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BEGINNINGS

While occupying the John Graham Kerr Chair of Zoology at the University of Glasgow, Professor David Crompton organised opportunities for students reading the Honours Degree in Parasitology to spend supervised summer visits in places where parasitic infections were endemic. Two such students, both qualified nurses, went to Sierra Leone to assist during the summer of 1992. Funds had to be found to support such visits and in their case *The Sunday Post* ran an article appealing for support for the "Angels in Doc Martens".

More money was donated than was needed to send and support the nurses in Sierra Leone, and so Robert Ewen, then Secretary of the University Court, suggested that a charity/company might be established with the surplus funds to help children in need in Sierra Leone. The name "St Andrew's Clinics for Children (STACC)" was adopted, and STACC was formally established in 1992 by staff at the University of Glasgow with the mission of supporting clinics in sub-Saharan Africa to deliver primary health care to children in some of the poorest parts of the continent. Over the years since 1992, over 1.6 million African children have received treatments due to the generosity of STACC's donors and supporters, and we have been able to support the work of clinics in Ghana, Kenya, Nigeria, Sierra Leone, Tanzania and Uganda.

GROWTH AND DEVELOPMENT

Since 1992, STACC has raised funds to support the provision of basic health care for children in several countries and centres in sub-Saharan Africa. Each centre supported by STACC is identified below in order of establishment.

1992-2020 Sierra Leone

Registered as a National Non-Governmental Organization (STACC/SL) based in Freetown. Coordinator: Dr. Mary Hodges. Health care focused on mobile and fixed clinics, de-worming school-age children and infant feeding. Overall 1,004,960 treatments were delivered. Of these 470,831 were de-worming treatments delivered to school-age children between 2004 and 2009. This programme was then adopted by the Government of Sierra Leone into its national programme for the control of intestinal worm infections in school-age children. The health care team

continued to contribute with training for the national programme and the supply of medicines. With much of the work adopted by the Health Ministry, the centre was able to wind down in 2020.

1998 Nigeria
Registered as a National Non-Governmental Organization (STACC-ILEIFE) based at the health centre of Obafemi Awolowo University in Ile-Ife, Osun State (Fig. 1). Coordinator: Professor Samuel Asaolu. Health care is provided through mobile clinics visiting ten locations each month. Children under five years of age have top priority and 37,995 children in this age cohort have been registered and receive treatment as necessary. Malaria is a major problem in the area and insecticide-treated bed-nets have been purchased and distributed to reduce the transmission of malaria parasites. STACC-ILEIFE has just celebrated its 25th anniversary! To mark the occasion, the Clinic's director gave a short talk to STACC supporters in January 2024 on the activities of STACC Ile-Ife and the key challenges faced by his team. A recording of this presentation is available at https://www.standrewsclinics.org.uk/ileife-mi. A further five days of events were organised in Nigeria (11th -15th March 2024), including an anniversary lecture, entitled "Care of children at a time like this".

Fig. 1. STACC Ile-Ife health care team. (Photo: Professor Samuel Asaolu)

2003-2018 Pemba Island, Zanzibar, Tanzania
Registered as a health centre of the Ministry of Health and Social Welfare. An outreach service began in 2004 in addition to the base clinic at Gombani. Coordinator: Mr Yahya Al Sawafi. The base clinic at Gombani and the outreach service have provided over 20,000 treatments for children annually. Insecticide-treated bed-nets were distributed to reduce the transmission of malaria pathogens. Mothers were also cared for. According to the World Health Organization, the health care supported by STACC and the Ivo de Carneri Foundation (IdCF) was the only free health care available on Pemba Island with its population of about 350,000. STACC provided 60% and IdCF 40% of support. At the time of support ending in October 2018, 330,000 treatments had been given. Sadly, the decision to withdraw from Pemba was taken partly because IdCF appeared no longer to have funds, and STACC could not take on the full commitment.

2003 Uganda
Children's ward at St Kizito Hospital, Matany, Karamoja. The hospital is registered with the government of Uganda. Coordinator: Brother Guenther Naehrich. Since STACC began to support the Children's Ward at St Kizito Hospital, approximately 90,000 children have been admitted as in-patients. STACC contributes approximately 36% of the costs of running the children's ward. The main diseases treated are malaria, upper respiratory tract infections and intestinal disorders. However, nutritional problems amongst young children are a continuing challenge. The hospital seeks to provide additional nutrients for local children and STACC supports this by providing funds to cover the cost of a vegetable garden and the purchase of a small flock of goats for a supply of much-needed milk.

2007 Kenya
The BION project is registered with the Government of Kenya's Department for Gender and Children, serving a Maasai community around Lake Magadi. Coordinator: Ms Seleina Limion. Nearly 8,000 children have been reached directly or indirectly through their mothers with insecticide-treated bed-nets, safe water containers, and better personal and home hygiene. Food is regularly distributed for the children. In 2019, STACC responded in principle to a request from BION to begin a female genital mutilation (FGM) awareness programme. It has taken some time to organise, but this project is finally about to begin, in spring 2024.

2008 Ghana
Registered as a Non-Governmental Organization (StACC Ghana), based in Bongo District. Coordinator: Dr Michael Wilson. Initially, health and dental education were provided in primary schools, and dental operations carried out by mobile teams in remote districts. The team then participated in the national programme for schistosomiasis control with the treatment of 22,945 school-age children in Bongo District. A major health education programme has been introduced into the Bongo District school system. More recently, STACC funded the purchase of a ventilator in the Paediatric ICU in KAT Hospital, Kumasi, which is essential in the management of critically ill young children, and funded the refurbishment of counselling space.

2016 Uganda
Children's ward at St John's Hospital, Aber, a private not-for-profit hospital registered with the government of Uganda. Coordinator: Nassuna Rose (Sister Rosemary). The children's ward at St John's Hospital has 42 beds, and 4,500 admissions annually. STACC covers 36% of all costs of running the ward.

2022 Malawi
At the Masambuka Clinic, STACC-Malawi will provide

essential primary health care for children in Machinga District, a rural community in one of the poorest areas in Malawi. Coordinator: Professor Mwapatsa Mipando. STACC has provided initial capital to finance a new clinic building at Masambuka, including funding for a solar energy plant to power refrigerators to keep medication fresh. Once established, STACC has agreed to make quarterly payments for treatments for children in the community for an initial period of five years.

STACC'S IMPACT ON HEALTH CARE

In the period 1993 to 2023, STACC received donations from the public amounting to £2.75 million. STACC holds approximately £200,000 in reserve to offset unexpected problems caused by political unrest, epidemics, natural and man-made disasters and other identified risks. Of the remainder, more than 95% is spent by African health workers at the seven health centres supported by STACC, and the remaining percentage on essential insurance, audit fees, company secretarial services/governance, fund raising, and printing.

Malaria, respiratory tract infections and intestinal worm infections remain the most common among the many other ailments treated. Over 1.5 million children have benefitted from medical treatments, but STACC also provides nutritional interventions and essential equipment to aid the work of the clinics. Equipment such as 4WD vehicles, motorbikes, phototherapy units for treatment of jaundice in newborns, anaesthesia equipment, ultrasound scanners, microscopes, portable generators, hundreds of insecticide-treated bed-nets, and plumbing for reliable water supplies. STACC has also sent funds to the Uphill Trust in Uganda to complete construction of a latrine block for girls and for the Trust to employ a school nurse.

STACC is managed by a Board of Directors, of which the author is a member, who work on a purely voluntary basis and receive no payments or expenses. The Board is currently chaired by John Briggs, (previously Professor of Geography and Clerk of Senate at the University of Glasgow, and a specialist on development in Africa) and meets four times per year to discuss governance requirements, review the work of the clinics, agree funding levels for the coming quarter, and discuss future fund-raising activities and development priorities. David Crompton is now Honorary President. STACC's accounts are inspected annually and published on the website of the Office of the Scottish Charity Regulator (OSCR).

STACC adheres to the following important principles and values:

- All clinical and managerial decisions are taken locally by the clinics themselves, not by the STACC Board in Scotland.
- All treatment and medication is free of charge at the point of delivery
- supported clinics must commit to using only *bona fide* medicines in their treatments.
- Supported clinics must commit to having in place clear policies relating to equality and diversity procedures and to safeguarding.

The Board is grateful for the generosity and interest of the many donors who have supported STACC since this amazing small charity was founded in 1992. We hope STACC will continue to go from strength to strength, and we hope readers will look at STACC's website and consider becoming donors themselves (https://www.standrewsclinics.org.uk/).

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Research on fish at the University of Glasgow

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Although John Graham Kerr himself worked on lungfish, there was very little subsequent research on fish until the late 1970s. An exception was the 1963 PhD conducted by Peter Maitland on the ecology of the River Endrick (the main river flowing into Loch Lomond), which had a focus on five species of freshwater fish (Maitland, 1965), and some work on powan (*Coregonus clupeoides*) in the 1950s as part of Harry Slack's studies of the ecology of Loch Lomond. Peter went on to have a distinguished career with the Institute of Terrestrial Ecology, becoming one of the foremost fish ecologists in the U.K. and a pioneer in the conservation of rare species of fish.

Most of the research on aquatic organisms in the department in the 1970s was on invertebrates, although Peter Spencer Davies extended his main line of work on coelenterate metabolism to supervise Malcolm Jobling's PhD on the digestive physiology of plaice (*Pleuronectes platessa*) (Jobling & Davies, 1980). Malcolm went on to take up a position at the University of Tromsö in northern Norway, where he became internationally known for his work on the physiology of fish (in particular those associated with cold water fish farming, such as Arctic charr - *Salvelinus alpinus*, and Atlantic salmon – *Salmo salar*).

The arrival of Felicity Huntingford was the start of fish behaviour becoming a key area of departmental research (Huntingford *et al*., 2024). Her group initially studied the aggressive, anti-predator and breeding behaviour of three-spined sticklebacks (*Gasterosteus aculeatus*) (Giles & Huntingford, 1984). This species has a long history of being used for behavioural research, due to the ease with which it can be reared and induced to breed in the laboratory. A chance discussion between Felicity and

John Thorpe from the Freshwater Fisheries Laboratory at Pitlochry led to a long-term and very fruitful collaboration between them both and with me; I was initially taken on in 1985 as Felicity's postdoctoral research assistant but later became an independent member of the academic staff. John had access to excellent salmon-rearing facilities (something the department lacked), which opened the way to many studies of the links between behaviour, growth and life histories in salmon (e.g. Metcalfe *et al.*, 1989). The facilities for holding salmon and related species such as Arctic charr and trout slowly increased - initially at the field station on Loch Lomond (Adams, 2024) but later in the Graham Kerr Building. However, it has never been possible to hold fish as large as adult salmon or trout in either of the Glasgow University locations, so all studies based on fish held in our facilities have been on small species or the juvenile stages of larger ones.

Felicity's research (together with Colin Adams, based at SCENE) gradually became focused on the welfare of farmed fish (Huntingford, 2024). Meanwhile I collaborated with Jan Lindström on the behavioural ecology of swordtails (Poeciliidae) and sticklebacks (Lindström *et al.*, 2009), and then began to specialise on the consequences of individual variation in metabolic rate and mitochondrial efficiency in a range of species of freshwater fishes. This work was initially focused on aquarium-based studies, but then extended to working in semi-natural stream tanks and finally full-scale field experiments in salmon streams in northern Scotland (Fig. 1), which showed that a fish's metabolic rate influenced its habitat choice and survival (Auer *et al.*, 2020). A theme of linking variation in metabolic rate to behavioural variation was strengthened by the arrival in 2009 of Shaun Killen, who brought expertise in measuring the swimming performance, shoaling and temperature preferences of fish (Killen *et al.*, 2015).

Fig. 1. Researchers from the University of Glasgow using a backpack electrofishing kit to survey juvenile salmon populations in a highland stream. Studies of salmon and trout have formed a major focus of fish research in Glasgow. (Photo: N.B. Metcalfe)

In the 1990s Colin Adams started a major field-based study of the extensive variation in the morphology of Arctic charr populations living in the freshwater lochs of Scotland, documenting multiple examples of lochs that held separate populations of both pelagic and benthic morphs, differing in diet, appearance and life history (Adams *et al.*, 1998). The later arrival of the evolutionary biologists Kathryn Elmer and Kevin Parsons extended this study into analysis of the genetic basis and evolutionary history underlying the observed extreme morphological variation in this species (Mable *et al.*, 2024). Over the last decade Kevin has also led a large-scale study that has examined whether Icelandic populations of the three-spined stickleback living in ponds heated by geothermal sources are different from stickleback populations living in neighbouring unheated ponds, and whether any such differences are due to evolved changes or within- or between-generational phenotypic plasticity (Pilakouta *et al.*, 2023). This study system of a "natural experiment" provides an excellent model for how fish might respond to climate change.

While the majority of the research on fish in Glasgow has focused on species in fresh water, the arrival of David Bailey has led to work on marine fish, especially those living in deeper waters (Bailey *et al.*, 2009); marine biology in Glasgow is covered in more detail by Meadows (2024). Given the importance of salmon farming to the Scottish economy over the last 30-40 years, it is not surprising that there have also been links with the aquaculture industry. These have recently been given a boost by the work of Martin Llewellyn and Sofie Spatharis, who are developing a major collaborative research programme aimed at making Scottish aquaculture more sustainable through better disease control for farmed salmon and the development of more sustainable feeds.

The facilities in the Graham Kerr Building for holding and quantifying the behaviour and performance of fish have improved gradually over time, despite the building not having originally been designed for this purpose. Much credit for this goes to Graham Law, the manager of the animal facilities in the building, who lobbied hard to secure the funding and then designed and oversaw the renovation of the aquarium rooms. This involved much logistical juggling, as it was necessary to renovate rooms one at a time in order not to halt ongoing research projects, yet moving projects between rooms was difficult as the rooms had different capacities, types of tank (to suit particular species) and range of temperatures over which they could operate. Once completed, these improvements allowed the scope of projects to increase in both scale and duration: recent projects have included studies spanning multiple generations (e.g. to measure the evolutionary effect of contrasting selection pressures, or to test whether the effects of environmental change can be passed on to offspring through non-genetic means). The Graham Kerr Building and SCENE (Adams, 2024) have developed complementary facilities, with the Graham Kerr being more suited to studies involving many replicate fish tanks (e.g. breeding studies) while SCENE has two experimental stream tanks that allow research on the behaviour of fish in semi-natural conditions (for example, studies of shoaling or territorial behaviour).

Field studies on fish have continued since the pioneering work of Peter Maitland, but the nature of the work has changed in the last decade due to the development of acoustic tracking systems that allow recording of the movements of fish in their natural environment. This can be over a range of scales: Shaun Killen's group have used this technology to quantify the detailed space use of individual fish within a small freshwater loch (the Dubh Lochan at SCENE), while Colin Adams and collaborators have tracked the movement of salmon smolts over long distances down rivers and out into the Atlantic, shedding new light on their migration routes, speeds and survival rates at the start of the marine phase of their life cycle (Lilly *et al.*, 2024). It is also worth recording that for over 25 years there has been a mutually beneficial association between the University and the Clyde River Foundation (CRF), an independent charity that is dedicated to research and education on the aquatic environment of the River Clyde catchment. The University has provided a base for the CRF and affiliate University status for its staff, and in return members of the CRF have contributed to teaching students about freshwater biology and conservation, provided opportunities for field-based undergraduate and graduate student projects, and collaborated with the University's fish biologists.

As with any area of scientific research, the focus of fish research in Glasgow has changed over the years, because of changes in academic staff and their interests, technological developments opening new opportunities, and societal changes in the perceived areas of greatest importance affecting funding opportunities. Thus, while it is likely that research on fish will continue at the University for many years to come, it is difficult to predict its nature, although there is likely to be a continued interest in the responses of both wild and cultured fish to environmental change, and in sustainable aquaculture.

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A century of research and teaching in animal behaviour and welfare in the Graham Kerr Building

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John Graham Kerr knew well that how animals behave has important consequences for many aspects their biology. In his book *Evolution* (Kerr, 1926) he describes how both the foraging strategies of visually-hunting predators and the protective habitat selection and immobility of their prey are critical for the effectiveness of animal camouflage. He also gives an account of the importance of nest building in the evolution of sociality in insects. An interest in animal behaviour was therefore represented within the Graham Kerr Building (GKB) from the start. The ensuing century has seen many important developments in behavioural biology, both reflected in and promoted by the research carried out in the building. An early example of such a development was the emergence in the 1960s of ethology as a recognised discipline for the biological study of behaviour. Ethology is characterised by focusing on spontaneous natural actions and by addressing all four of the questions that Niko Tinbergen famously identified as essential for understanding behaviour: What is it for? How does it develop in an individual animal? How did it evolve over the history of the species? How does it work? (Bateson & Laland, 2013).

A key role in the history of behavioural studies in the GKB was played by Samuel (Tony) Barnett (1915-2003), a graduate in Zoology from Oxford University, promoted to Chair of Zoology at Glasgow before moving to the Australian National University in 1973. His main research interest was the behaviour of rats, summarised in his most famous book (Barnett, 1963), based on his work on wild and laboratory rats in nature and in captivity. Barnett's approach was unusual for a zoologist of the time in combining elements from ethology and comparative psychology, reflected in his clear recognition that the simple distinction between instinctive and learned behaviour drawn by many ethologists was misleading. Barnett was also unusual in discussing emotions in rats (albeit firmly placed in inverted commas) and their underlying physiological bases. One of his graduate students, David Fraser, moved from Glasgow to Edinburgh while still writing up his PhD thesis on social and exploratory behaviour of laboratory rats and mice. In Edinburgh he started a highly distinguished career in animal welfare (taking him to the University of British Columbia, Vancouver) with some of the earliest research on the welfare of intensively reared pigs. Barnett's expertise in rat behaviour had been put to practical use during World War 2, when he advised the British Government on the possibility of an epidemic of bubonic plague. In a sense, this looked forward to the strong epidemiological theme developed later by researchers in the GKB.

Another important and influential zoologist, Mike Hansell, was recruited in 1968 by David Newth, then Regius Professor, to strengthen research and teaching in animal behaviour in Glasgow. He came from the University of Khartoum, having gained his doctorate at Oxford, on case building in caddis flies. In Glasgow, Hansell continued his broadly-based studies of animal architecture, with a special interest in nest building by insects and birds. In this context, Hansell established the National Nest Reference Collection of the Hunterian Museum. His research addresses all of Tinbergen's four questions, from the development of case building in caddis larvae, to the evolution of nest building in social insects and the functions served by bird nests. An important aspect of Hansell's work on the causes of behaviour is his demonstration that impressively complex structures can be generated by relatively simple actions. His internationally recognised academic research has always been accompanied by a commitment to public engagement, through popular books, for example *Built by Animals* (Hansell, 2007) and exhibitions such as *The Animal Construction Company*, devised in 1999 with collaborators in the Hunterian Museum as part of Glasgow's year as City of Architecture and Design. Hansell, a highly effective and popular teacher, was responsible for consolidating animal behaviour as a recognisable discipline within the zoology curriculum taught in the GKB.

From the late 1970s onwards, further important developments took place in how zoologists studied behaviour, including an increasingly interdisciplinary approach, with behaviour being seen as not so much an isolated trait, but as contributing to, among other things, ecological adaptations, physiological processes and life history patterns. This broader approach was facilitated by revolutionary advances in molecular biology and computing science. An additional trend was towards increasingly putting knowledge about behaviour to practical uses. Again, such developments were both reflected in and promoted by research carried out in the GKB.

Felicity Huntingford moved from Oxford to Glasgow in 1974 to join the zoologists working in the GKB, also appointed by David Newth. Her research focuses on the behaviour of fishes, particularly on the marked individual differences they show when challenged by a rival or a predator. She developed and broadened this theme through collaborations with colleagues from other disciplines, including physiologists, molecular biologists, life-history biologists, theoretical ecologists, fisheries scientists and veterinarians. Aggression and anti-predator behaviour are both areas that raise ethical questions when studied in captive animals and

Huntingford was involved in drafting the first statement on the ethics of animal behaviour research (Huntingford, 1984), developed to promote good ethical practice in articles submitted to the journal *Animal Behaviour*. These guidelines were adopted by the Fisheries Society of the British Isles and, consequently, Huntingford was asked to prepare a briefing paper on fish welfare for the Society, subsequently published as a review (Huntingford *et al.*, 2007). Her interest in fish welfare reflects a general shift towards using knowledge about natural behaviour to promote sustainable and welfare-friendly aquaculture. This trend has now moved into the treatment of complex invertebrates such as decapod crustaceans, as studied by another GKB researcher, Douglas Neil (Albalat *et al.*, 2022)

Many more researchers based in the GKB than we have space to mention have worked on topics that involve animal behaviour. Particularly eminent among these are the current Regius Professor of Zoology, Pat Monaghan (also appointed by David Newth), whose work on reproductive behaviour, life history patterns and conservation in birds is described in a separate article, and Neil Metcalfe, who investigates the behaviour of fishes, among other animals, in relation to their ecology, life history patterns and conservation, also covered separately.

The welfare strand in research and teaching in the GKB has been strengthened and expanded by later recruitments and recently (in 2022) by the establishment of the School of Biodiversity, One Health and Veterinary Medicine. This brings together staff and students from across the University and includes the research theme of Physiology, Ageing and Welfare, the aim of which is to improve the health and wellbeing of domestic and wild animals. Among these later recruits, Ruedi Nager came to the GKB in 1996, having gained his PhD in Switzerland (Basel) and working as a postdoctoral researcher in the Netherlands (Groningen) and France (Montpellier). Nager's research focuses on how organisms (mainly birds) cope with the environment in which they live. This has included experimental studies of the effects of stress on reproductive strategies in laboratory-reared zebra finches, which led him naturally to an interest in monitoring and protecting the welfare of his own study animals. In this Nager was greatly helped by Graham Law, responsible as Named Animal Care and Welfare Officer for the welfare of all captive animals kept in the GKB. Law used his considerable intellectual and technical skills and his vision for enriched living spaces to improve the welfare of the animals in his care. The combined expertise of Nager, Law and Michael Wilkinson (the named Veterinary Surgeon) led to their being commissioned to develop guidelines on the welfare of captive zebra finches for the Universities Federation for Animal Welfare first in 2010 and updated in 2024 (Nager *et al.*, 2024).

This aspect of Nager's work has involved close collaboration with Dorothy McKeegan, who studied for a BSc in Zoology in the GKB in 1994, before moving to Edinburgh. Here she gained an MSc and PhD in behavioural, physiological and ethical aspects of animal welfare and subsequently worked at the Roslin Institute. McKeegan came back to Glasgow in 2005 to a lectureship at the Veterinary School, initially part-funded by the British Veterinary Association Animal Welfare Foundation to promote teaching of animal welfare science and ethical issues to veterinary students. Her research integrates behavioural, physiological and neurophysiological techniques to improve the welfare of captive animals; her findings have influenced U.K. legislation on beak trimming in laying hens and EU regulations on Low Atmospheric Pressure Stunning in poultry. McKeegan is also interested in developing novel methods for assessing welfare and affective state, one of which has brought her together with Nager and Dominic McCafferty, an ecologist who has been associated with the University of Glasgow since 1999, both in the GKB and at SCENE. McCafferty's research focuses on thermal adaptation, behavioural thermoregulation and microclimate selection in mammals and birds. Drawing on common interests and complementary expertise, Nager, McKeegan and McCafferty collaborate to explore (among other things), the use of a novel, non-invasive technique based on thermal imaging to monitor stress and welfare in captive hens, captive rats and wild blue tits (Fig. 1).

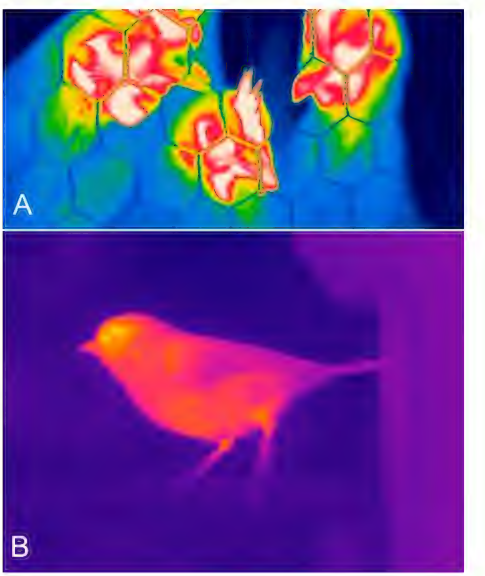

Fig. 1. Thermal images of (A) hens and (B) a blue tit. The images are false colour images translating surface temperature into colours ranging from white and yellow (highest temperatures) to blue (lowest temperature). Both images show clearly the warmest body regions of each bird and these are the regions that cool when an individual is exposed to a stressor. (Photos: (A) Kathrine Herborn and (B) Paul Jerem)

This strong research theme in animal welfare is well represented in the programme of teaching and training run from the GKB. Both McKeegan and Nager make

important contributions to Home Office Personal Licence Training courses, based on their expertise in the ethics of using animals and in handling birds, respectively. Research projects about animal welfare have been offered to many students in the taught MRes programme, and since 2011 through the dedicated MSc in Animal Welfare Science, Ethics and Law, currently training 15-20 students per year, from diverse backgrounds and many different countries.

In summary, animal behaviour has been a key component of research and teaching since the opening of the GKB and through the ensuing century. This has seen successive researchers and teachers addressing fundamental and applied questions, working with a wide variety of animals, in the laboratory and at field locations across the U.K. and overseas. The contexts in which behaviour has been studied and the tools for doing this have changed greatly, but at core the fundamental questions are the same and we probably all spoke and still speak the same zoological language. Barnett would have been intrigued to see his hunch on the possible physiological bases underlying "emotions" in rats come in full circle with the help of modern imaging technology and Graham Kerr would certainly have had much to discuss with Hansell about his work on the evolution of nest building in social insects. In contributing to animal welfare, conservation and disease control, animal behaviour research based in or linked to the GKB continues to help Glasgow University to fulfil its responsibility to contribute to matters of public concern.

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Developmental and reproductive biology

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John Graham Kerr's (JGK) primary research interest was in the development of the "lower" vertebrates, and his main research material the extensive collections of preserved lungfish (*Lepidosiren paradoxa*) embryos made on his second trip to South America (1896), supplemented by specimens of *Protopterus annectens* and *Polypterus senegalus* collected by J.S. Budgett from west Africa. Although JGK published on the behaviour of lungfish, most of his work, begun in Cambridge and continued in Glasgow, was on the developmental stages of organ systems as revealed in histological sections of the preserved material. A clear objective of this work, following Darwin's *Origin of Species* chapter on embryos, and later work by Ernst Haeckel and others, was to discover what the development of "lower" vertebrates could reveal about the origins of the organ systems of "higher" vertebrates. This research in Glasgow was highly dependent on the skills of his histology technician P. Jamieson. Some of JGK's Glasow colleagues contributed to this research programme, notably E.S. Bles and W.E. Agar, but embryology gradually petered out as a Glasgow zoology interest.

This situation changed with the appointment of David Newth as Regius Professor in 1965. His previous post was Professor of Biology as Applied to Medicine at Middlesex Hospital Medical School, and he was closely associated with a group of cell and developmental biologists at University College London such as Ruth Bellairs, Michael Abercrombie and Adam Curtis (who also later moved to Glasgow to head a new department of Cell Biology). He was also the second editor of the *Journal of Embryology and Experimental Morphology* (*JEEM*, later *Development*), succeeding Abercrombie. In Glasgow, Newth quickly established an aquarium room in the basement for the breeding of the African clawed frog (*Xenopus laevis*), the amphibian species of choice for developmental biologists because it could easily be induced to breed (Bles had published a paper on hatching in *X. laevis* embryos when in Glasgow), and Axolotls (*Ambystoma mexicanum*: Newth was interested in the origins of colour variants in this species). Newth

also set up an experimental laboratory next door to his office, and his research team, initially Jean Clark and later also Ken Crockett worked there. Newth's strengths were in teaching and administration rather than research, and the published output of the laboratory was meagre. However, he was soon to raise substantial external funding that allowed the recruitment of Donald Ede (Fig. 1) from Edinburgh, and the establishment of a Developmental Biology Unit in a Victorian villa at Horselethill. This was fitted out with extensive animal house facilities, staff offices and experimental laboratories. Academic staffing in developmental biology had already been strengthened by the appointment of Suzanne Ullmann (insect embryologist; later working on marsupial mammal reproduction) and Roger Downie (avian embryologist; later working on amphibian reproductive adaptations and marine turtle conservation): both moved to the new unit along with histologist Cathie Morrison. Ede's interests were in what mutations of limb development could reveal about the processes of normal development: his work focused on two avian mutants - *talpid*[3] and *ametapodia*, and a mouse mutant - *pupoid foetus*. Maintaining breeding stocks of these mutants was a complex, time-consuming and expensive process, but the research output was substantial. Ullmann's interests in marsupials stemmed from a sabbatical visit to Australia, and for a time the Horselethill building housed the biggest breeding collection of some marsupial species north of the Equator! One researcher we sadly could not keep was Peter Thorogood, in Glasgow for a year in the 1970s. He went on to a stellar career in the field of skeletal defect development, before his untimely death in a fall from the Jungfrau, Switzerland at age 51.

Newth's other main initiative was the establishment of an undergraduate degree in developmental biology, as part of a strategy to attract medical students to zoology-related courses. Medical students (including those studying Dentistry and Veterinary Medicine) were able to pause their main studies for two years in order to complete a BSc degree in a medical-related subject, such as Anatomy. For the Zoology Department, the possible medical-related subjects were developmental biology and parasitology (for veterinary students, zoology itself is appropriate, especially for those interested in medicine related to exotic species). With teaching demands growing, colleagues needed some persuading that designing and teaching two new degree courses for possibly small numbers of medical students was a sensible strategy. Newth got his plan through by arranging that the new courses would be collaborative, bringing in staff from other departments, and ensuring that the course would be offered to science faculty students as well as to medicals.

The degree in Animal Developmental Biology (ADB) accepted its first students in 1974, and was initially a collaboration between the Departments of Zoology and Anatomy, with significant input from molecular biologists of the Beatson Institute for Cancer Research. Later, Cell Biology and Plant Science staff also contributed, with the name changing to Developmental Biology. It is not clear why plants were at first excluded.

Fig. 1. Donald Ede photographed at work in his laboratory in Edinburgh, a few years before his move to Glasgow: rather formally dressed! (Photograph provided by his family)

Newth was a strong advocate of the integration of the biological sciences, and in his review (Newth, 1986) of a history of developmental biology, he was critical of the lack of coverage of plants, as well as, in typically witty fashion, of the over-abundance of misprints! It was perhaps considered that inclusion of plant development would discourage medical students from taking the course. Over its 24 years, the course produced 96 honours graduates (four per year on average), and so numbers were not large. Ironically, the course closed (as a result of the non-replacement of retired staff) just when numbers peaked at 12 in 1998.

Science students entering the degree programme at level-3 would have encountered aspects of developmental and reproductive biology in Biology-1 and in some level-2 courses. Medical students would have learned aspects of development in anatomy courses. Level-3 then provided them with a comprehensive overview of the scope of the subject: see Downie (2024) for titles of the modules delivered in the mid-1990s. An important aspect of the course was the tutorial programme, which had a clear set of aims and content covering graduate skills, and the societal and ethical aspects of the subject and the nature and limitations of science (Table 1). The tutorial programme included a two-night residential discussion weekend at Rowardennan, substituting for the field courses

Aims
• To develop skills in researching information using original sources, and in presenting it in written and in oral form. • To develop skills in writing about science in different forms. • To develop a critical and individual outlook in reading scientific reports. • To develop listening and responding skills, and an ability to see other people's viewpoints, by taking part in discussions on controversial issues. • To investigate topics in reproductive and developmental biology that have relevance to people's lives e.g. fertility control and problems of infertility, both from a scientific and bioethical viewpoint. • To develop an understanding of the nature of science and how scientists work.
Topics covered (15 meetings, seven assignments)
• Human fertility control. • Is there a world population problem? • The reproduction revolution. • How science works/Limits to science. • Critical analysis of scientific papers. • Biotechnology: problems with patents and other dilemmas. • The exploitation of animals. • Human congenital malformations. • Ageing.

Table 1. Aims and content of the developmental biology tutorial programme.

provided for the other zoology-related programmes. The relatively small numbers studying developmental biology allowed the discussion weekend to have both level-3 and level-4 students together in an informal teaching atmosphere along with academic staff.

Over the first two terms of level-4, students took four five-week advanced modules (30 hours each) from a selection offered across the biological sciences: the ADB degree offered two such courses- Cellular Morphogenesis and Problems in Mammalian Reproduction. Term 3 offered a short lecture course on contemporary Issues. In addition, each student undertook a supervised research project over terms 1 and 2, taken in one of the contributing departments.

Although the degree course closed in 1998, aspects of the teaching continued as components of the degrees in Zoology and Anatomy. The strong emphasis of the degree on mammalian reproduction meant that a significant number of graduates progressed to careers in the infertility services, including *in vitro* fertilisation.

Developmental and Reproductive Biology in Zoology has now come full circle with the establishment of Kevin Parsons' research group, which works on the relationship between evolution and development, like JGK, and Kathryn Elmer's which studies the evolution of viviparity in lizards.

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Insects (and some other terrestrial arthropods): a perennial theme

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The ubiquity of insects, their broad ecological and biological interest and their economic importance, have ensured the persistence of entomological teaching and research throughout the history of the Department of Zoology at the University of Glasgow. Also, from the museum point of view, insects have had a high profile dating from the foundation of the Hunterian Museum and the insect cabinets of William Hunter, who had engaged J.C. Fabricius as his curator from 1772 onwards. This is one of the three substantial surviving collections containing primary type specimens of Fabrician names. The others are his own in Kiel, Germany and in that of Joseph Banks in London. J.G. Kerr's role in curating the Hunterian zoological material is described in *Gallery of Memories* (this volume).

Several entomological themes and research by staff are described here briefly, the majority being from 1953 onwards. Some references as examples of their work are given at the end. Within the Department of Zoology undoubtedly the most famous entomologist was Roy Crowson who spent his life and career studying the Coleoptera. One of the principal sources of specimens for his morphological and anatomical research was the extensive beetle collection of T.G. Bishop (1846-1922)

that came to the Hunterian in 1923. As Roy Crowson's wife Betty expressed in her introduction to Roy's 80th birthday two volume *Festschrift*: "Major regrets are that [now] no Glasgow grocers are interested in beetles …" (Crowson, 1995). The explanation of this phrase is that Bishop, profiting from his Coopers grocery business (later Coopers Finefare supermarket chain), was able to develop his hobby by purchasing entire collections through dealers and auctions on a world scale. Roy's output, in addition to 200 papers, included three books (Crowson, 1955, 1970, 1981). Information on his activities in Glasgow is provided by Hancock & Robinson (2021).

During the last century it has been mainly the economic impact of insects on humans that has driven insect research and teaching. Their medical importance, particularly as vectors of diseases, was of interest to Edward Hindle, J.G. Kerr's successor as Regius Professor, who encouraged entomological work. In 1935 Hindle was able to obtain an important synoptic collection of mosquitoes from the private collection of F.V. Theobald (1868-1930) to support such research. Alex Haddow (1912-1978) discovered the Zika virus and vectors of yellow fever in Africa, later completing his time as Professor of Administrative Medicine at the University and then Dean of the Faculty of Medicine. During World War 2, J.D. Robertson (1912-1993) served in the Army Medical Corps researching mosquito vectors of malaria and the effect on soldier training and efficiency when operating in tropical situations. After returning to work in Glasgow, Robertson deposited large numbers of preserved mosquitoes, mainly from West Africa, but then turned his attention to non-entomological interests. Today, mosquitoes are an important area of research and teaching through Professor Heather Ferguson and colleagues whose work embraces their role as disease vectors both in Africa and Scotland.

Biting midges were studied by Anthony Downes, J.W.H. Lawson and D.S. Kettle who found new species in Scotland (Downes & Kettle, 1952). Downes continued to work on this family after emigrating to Canada.

M.V. Brian (1919-1990), a specialist in ants, was appointed lecturer in 1946 and left in 1953 to manage the Freshwater Research Station at Furzebrook, Dorset (Elmes & Stradling, 1991). While in Glasgow he met a fellow entomologist also working on ant biology, Anne ("Anthea") D. Synge (1919-2007). They married in 1947 and published together (Brian & Brian, 1949). The next year they wrote on birds predating caterpillars using their home address in Cardross (Brian & Brian, 1950). This might imply that Anthea was obliged to resign from paid work as a married woman. Anthea's PhD (London) was followed by research on social Hymenoptera at Rothamsted Research Station. While in Glasgow the Brians started a family but after moving to Dorset they separated and she moved to Hereford. She became interested in and heavily involved with local history, archaeology and wildlife trust work maintaining her married name. A number of research students worked with M.V. Brian. These included J.S. Weir (1951-1954) who moved to University College, Salisbury, Rhodesia (now Harare, Zimbabwe) in about 1958 (Weir, 1959), and D.W. Hall (Hall & Smith, 1954). The best-known work on ants by Brian is the volume in the Collins *New Naturalist* series (Brian, 1977).

Pamela Allen (1929-2019) graduated in Zoology, Queen's University of Belfast in 1951 and was awarded a Northern Ireland Scientific Research Maintenance Grant for three years. This was spent mainly at the Silwood Field Station run by Imperial College (London) where she started research on Agromyzidae (Diptera). Some of this family of phytophagous leaf-mining and stem-boring flies are important crop pests (Fig. 1). She lectured in Glasgow from 1955 working with Alex Hill during which time she continued her research and published the results (Allen, 1957) but left in 1958 for Ghana where she and her husband, John ("Ian") Forsyth (1929-2023), also an agricultural entomologist, worked for several years. A collection of Agromyzidae Allen donated to the museum in 1954 also contains some parasitoid wasps she reared from agromyzid immature hosts.

Fig. 1. Pamela Allen at her bench at Silwood Park, Imperial College Research Station, Berkshire (July 1952). (Photo: Tony Irwin)

Elspeth (christened Elizabeth) M. Cawthra completed her PhD on weevils (Coleoptera, Curculionidae), supervised by Roy Crowson, in 1957. One of her papers (Cawthra, 1957) was illustrated with figures by Peter Belton (1930-2019) who was studying for his PhD at the same time. Both he and P.N.R. Usherwood researched insect neuromuscular systems under Graham Hoyle. Peter Belton and Elspeth married and moved to the

U.S.A. and then Canada. Considerable detail of their life and career together is given by Hart (2019) even to the point of mentioning that Peter Usherwood lent his kilt to Peter Belton so that he could go to Scottish Country Dancing classes in his wooing of Elspeth.

Suzanne L. Ullmann (1935-2014) came to Glasgow in 1967 having researched on the developmental biology of insects for her PhD (London) and during three years in Edinburgh's Institute of Animal Genetics. Suzanne used the common mealworm, *Tenebrio molitor*, as her target species (Ullmann, 1973). A large number of serial sections of mealworm larvae etc., and copies of her papers are deposited in the Hunterian. After a few years, following a visit to Australia, she changed to study marsupial reproductive systems, establishing captive breeding populations of potoroos (*Potorous tridactylus*) and opossums (*Monodelphis domestica*) in Glasgow. This work continued after her retirement during which time she also obtained a Bee Masters Certificate from the Scottish Beekeepers' Association. That led to her being in much demand for lectures on apiary, judging honey competitions and attending international conferences on the subject. Ken Lockey joined the department in 1959 and pursued his research into the diversity of the lipids that waterproof insect cuticles (Lockey, 1985). Ken's research was limited by his heavy teaching responsibilities, especially to medical students. Another investigation into how insects are so successful was pursued by parasitologist Ann Lackie (in post 1976-1988) who worked on how their immune systems cope with parasites: she surprised us all by resigning to pursue a new career in creative writing and broadcasting, which she has done successfully since as Ann Lingard.

Ron Dobson's work in Glasgow, starting in 1959, spanned a considerable range of entomological subjects including agricultural and stored product pests (Dobson, 1964, 1972). Insects such as leatherjackets (larvae of cranefly - pests of cereal roots and horticultural crops) and flea beetles (leaf-eating pests of cruciferous plants) were also of interest. Ken M. Stewart was supervised by Ron for his PhD on cranefly larvae in 1969 and went on to work in South Island, New Zealand for 16 years on grassland pests, before returning to posts at Ayr Technical College and then de Montfort University (Leicester). The commercially available larval extraction Salt-Hollick apparatus used by Ron (Fig. 2) was rejected by Ken in favour of his own design, published later (Stewart, 1974). Ron also researched scabies mites, of dermatological importance, and house-dust mites, ubiquitous domestic pest species that cause respiratory diseases in humans. One of Ron's last PhD students, Matt Colloff, worked on these animals for his PhD in medical entomology (1982-1985), followed by postdoctoral research on the immunology and epidemiology of allergic diseases. Matt moved to Australia in 1994. Connected with Ron's previous employment as an Inspector with the Ministry of Agriculture prior to starting in the University, specimens of stored product pests including some from ship-borne bulk materials arriving in the Clyde docks were deposited in the museum. As a result of enquiries

Fig. 2. Ron Dobson with the Salt-Hollick apparatus for extracting insect larvae from soils. (Photo: Hunterian Museum archives)

directed to various members of staff from the government bodies responsible for biosecurity, as it is now termed, these started to accrue during the immediate postwar period. New work on arachnids as disease transmitters is being pursued in the Scottish Highlands and Islands by a group led by Roman Biek, which is surveying ticks and their role in the spread of Lyme disease (Millins *et al.,* 2021).

Tony F.G. Dixon started his career in Glasgow from 1958. In addition to many papers on aphids his substantial and influential book on them was first published in Glasgow (Dixon, 1985). Two further editions followed with substantial revisions produced after he moved to the University of East Anglia in 1974. Dixon also supervised the research of Walter Edgar on the ecology of wolf spiders, resulting in several papers (Edgar, 1971) and his joining the Zoology Department's staff. Aphids were studied by Alex Hill (1919-2006) in connection with diseases in raspberries. He also worked on the heteropteran predatorial bugs - *Anthocoris* spp., and his collections were deposited in the museum (Hancock & Dobson, 2008).

The long connection with the Scottish Agricultural College (SAC) has had a strong element of entomology. Agnes A. Meikle (died 1951) was a lecturer from about 1930 based at the then West of Scotland Agricultural College in Blythswood Square, Glasgow. She had an interest in the dipteran family Tephritidae, many species of which have larvae that are leaf miners or fruit feeders. Her research files were deposited with C.M. Yonge by

Professor L.A.L. King, head of the College. Several papers were published on insect pests and species that attacked bracken that might have a role in its control (King & Meikle, 1933). Alexander Cuthbertson (1901-1941) graduated from the College and later was to supply insects from Rhodesia for teaching agricultural entomology on the courses at Glasgow (Hancock & Moore, 2017). Graduate degrees and doctorates supervised at the SAC were awarded by the University of Glasgow and there have been strong academic connections between staff, Professor Garth Foster, Professor Davy McCracken, Dr. Lorna J. Cole and Dr. Shona Blake whose work focused on insects.

Professor Mike H. Hansell used the building behaviour of insects as a major part of his research into animal architecture. Species studied ranged from caddis flies, moths and beetles that build protective cases, to the social insects - ants, bees, wasps and termites - and their nest building behaviour. The use of silk by moths and butterflies for cocoon construction, the web-spinners (Embioptera), as well as spiders, also featured. Mark R. Cole, one of Mike's research students, studied nest construction and development in vespine wasps for his PhD.

Museum-based entomologists manage access to the collections, lecture, supervise student projects, conduct research and provide identification services. Geoff Hancock was appointed in 1997 to deliver a Heritage Lottery funded project to upgrade storage and access for the insects, public programmes and an exhibition. Geoff later obtained a post as the first Hunterian Museum entomology curator and, after his retirement in 2015, Jeanne Robinson became Curator of Entomology. Research falls into a number of categories, some result directly from supervising Honours projects (Barabás & Hancock, 2000) or from active field work (Robinson & Hancock, 2008) and some particular taxonomic interests are pursued (Hancock, 2006). The historical importance of the collection has engendered a considerable output (Hancock, 2015; Robinson *et al*., 2018; Robinson & Vane-Wright, 2018).

In 2021, entomology was strengthened by the appointment of Oskar Brattstrom. He initially studied the migratory ecology of red admiral butterflies, but since 2005 has worked on the speciation patterns of the Satyrinae butterflies found in Africa, South-east Asia and Australia, investigating the roles of ancestral genetic constraints and local ecological factors (Brattstrom *et al*., 2020). His focus now moves to the conservation of Nigerian butterflies and, in Scotland, to stream invertebrates as bioindicators.

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The history and development of ecology and ornithology in the Graham Kerr Building

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When the Graham Kerr Building (GKB) first opened in 1923, animal ecology as a recognised discipline within the biological sciences was still very much in its infancy and taught in very few U.K. Universities. The British Ecological Society is the oldest ecological society in the world (established in 1913), and many of the key early figures in it were botanists. However, the publishing of Charles Elton's landmark book *Animal Ecology* (Elton, 1927) provided a scientific basis for the study of the ecology, behaviour, and life histories of animals. After the Second World War, the inspirational work of scientists such as David Lack intertwined ornithology, ecology and evolutionary biology, and interest in both ecology and ornithology expanded relatively quickly. Later, as the negative impacts of increasing intensification of agriculture and pesticide use on the natural environment became increasingly apparent, plus major impacts of land use change, over-exploitation and species persecution, the increasing interest and need for nature conservation brought ecology further into the foreground of biological science. Most recently, the twin crises of biodiversity loss and climate change, plus disease transmission from animals to humans, has meant

that the need to understand the impacts we are having on other species and ecosystems, and what we can do to deal with the problems we create, is ever more pressing. Ecology is now a very broad church, and this is reflected in the fact that Zoology in Glasgow now sits within the new School of Biodiversity, One Health and Veterinary Medicine, and ecological thinking is fully integrated into the teaching and research of many colleagues.

Over the years, ecological research has developed considerably in Glasgow, with additional research in behavioural and physiological ecology. This has involved research carried out by, under the supervision of, and in collaboration with, members of the academic staff. In addition, large numbers of independently funded research fellows have also made enormous contributions. So large and far-reaching has the subject become, that it is simply not possible to name all of those involved or all the research topics covered. This chapter mainly focuses on how a broad, fundamental, ecological base developed from the initial focus on avian-centred research in the 1970s, and is based on the academic staff and their interests. It by no means covers everyone or everything that has been done, but hopefully gives a historical record of the development of animal ecology in the GKB.

The first true ecologist at the University of Glasgow was a population ecologist, Anthony (Tony) Dixon, who was appointed to the Zoology academic staff in 1957. Tony studied the population ecology of aphids at the Rowardennan Field Station, Loch Lomond, where he ran a large experimental programme until he moved to the University of East Anglia in 1975. Peter Calow, a physiological and evolutionary ecologist, was appointed in 1972, with a particular interest in the costs of reproduction and a focus on freshwater organisms. Peter then moved from Glasgow to the University of Sheffield in 1984. The next ecologists to be appointed to the permanent academic staff worked primarily in avian ecology, beginning with the appointment of David Houston in 1974 as part of the expansion of Zoology that took place under the then Regius Professor, David Newth. David Houston initially worked with scavenging birds, such as vultures in Africa and crows (and later buzzards) in Scotland. As has been mentioned elsewhere in this volume, David Newth believed that, for a particular sub-discipline to flourish, appointing groups of three staff with cognate interests was a good approach, which indeed it was. One of the areas he specifically chose to develop was research on birds, leading to the appointment of two further staff members who worked primarily in avian ecology: myself (Pat Monaghan) in 1976 and Robert (Bob) Furness in 1978.

Ornithology in Glasgow has encompassed both applied and fundamental research, initially involving work in the field including large scale catching (using cannon-netting) and marking of gulls and shorebirds for studies of behaviour and movements. An "Applied Ornithology Unit" was established in the 1980s, under which conservation work was carried out. There was a large amount of research on seabirds, their population ecology and life histories, including the interaction of seabirds and commercial fisheries, with a focus on the breeding seabirds and industrial sandeel fisheries of the North Sea. Both Bob Furness and I had projects on this topic in Orkney and Shetland, and elsewhere. Bob was especially well known for his detailed long-term studies of the population of great skuas (*Stercorarius skua*) on Foula, Shetland, which ceased only relatively recently. As well as many scientific papers, Bob and I also published a book together on seabird ecology (Furness & Monaghan, 1987). Bob retired early from his university post in 2018 to focus on environmental consultancy work. I also studied the association of gulls with human environments and their potential role in the spread of disease. All three of us "ecological ornithologists" collaborated to varying degrees, while at the same time running independent projects, not always on birds. Ornithological research expanded further in the 1990s. Neil Metcalfe, who did his PhD on shorebirds with Bob, but who then became primarily a fish biologist (Metcalfe, 2024), was appointed in 1992 and has retained a research interest in birds. Ruedi Nager (initially a postdoc with myself and David Houston in the 1990s) and Stewart White were appointed to the academic staff in the late 1990s. A nice summary of the development of ornithology in Glasgow was published in Scottish Birds (Furness *et al.*, 2011), which described much of the work conducted until then. This includes both long-term individual-based studies of particular bird populations of high conservation concern, such as the great skuas on Foula (Furness, 1987) and red-billed choughs (*Pyrrhocorax pyrrhocorax*) in the Inner Hebrides (see Reid *et al.* (2021) for a recent summary of the chough research, which involves myself and many colleagues based elsewhere). Other Zoology staff, such as Martin Burns, initially an electrophysiologist, were drawn into the bird work. Martin was a wizard in the development of electronic kit for use in the field and laboratory, designing, for example, sophisticated radio tracking capabilities and remote weighing devices disguised as rocks for work on seabirds. Staff in the mechanical workshop (then based in the GKB) also did a great job in helping build the devices. This kind of work was then further developed in the Bioelectronics Unit, run until recently by Nosrat Mirzai, which continues to develop innovative, tailor-made devices to facilitate research and is still located in the basement of the GKB (Mullin *et al.*, 2024).

David Houston developed an interest in avian nutrition, especially in relation to egg production, and as part of this work established a colony of zebra finches (*Taeniopygia guttata*) housed in the GKB. David retired in 2011, but researchers in Glasgow carry out research using this species as a model to the present day – for instance my own group has conducted long-term projects following individual birds throughout their lives in studies of ageing biology and effects of early life conditions (Fig. 1). In 1996 Richard Griffiths set up one of the first molecular ecology labs in the U.K. and together with Kate Orr (now Griffiths) developed an innovative and now widely used method of genetically sexing birds using small DNA samples, generally

Fig. 1. Research using the zebra finch colony enables life-long effects of environmental conditions to be studied from the chick stage through to old age, and across generation. (Photo: Paul Jerem)

obtained from bird blood (Mable, 2024). This led the ornithology group in Glasgow and elsewhere into new research avenues on avian sex ratios, showing for the first time, for example in field work on lesser black-backed gulls (*Larus fuscus*), that the sex ratio in clutches of eggs can vary with the female's body condition (Nager *et al*., 1999). In parallel, Glasgow became known for experimental work on the costs of egg production in the field and laboratory (Monaghan & Nager, 1997), and on the long-term effects of early life conditions, particularly stress exposure and growth rate, on individual life histories (Metcalfe & Monaghan, 2001).

Further development of molecular tools has taken place in Glasgow enabling the study of cellular and organism ageing via telomere attrition, measured mainly from red blood cell DNA, and also molecular approaches to evolutionary biology (see Mable, 2024). Ruedi Nager has continued work on how gulls function in a human-dominated landscape, with his recent research being on diet, habitat use and movements of gulls throughout their annual cycle. Together with several other Glasgow colleagues, it was shown, using thermal imaging, that skin temperature can be used to measure stress exposure, which they have now used in both captive and wild birds, including northern gannets (*Morus bassanus*) on the Bass Rock and common guillemots (*Uria aalge*) in the Baltic (Herborn *et al.*, 2015). Stewart White is now focused on passerine birds in the wild, both locally and internationally**.** For example**,** the area around Loch Lee, on the border between Angus and Aberdeenshire, has long been a stronghold for the ring ouzel (*Turdus torquatus*), with several papers on this published by University of Glasgow staff and students (Davies *et al*., 2014). Monitoring of the population is ongoing, but sadly the drop in numbers seen in other populations does now appear to be affecting the Loch Lee birds. Stewart has also studied the bearded reedling (*Panurus biarmicus*), another species with a stronghold in Scotland.

More passerine work was developed with the arrival in 2012 of Barbara Helm, known for her work on avian migration and biological rhythms. Barbara built up work that had been developing on nest-box populations of tits in the woodlands around the SCENE field station on Loch Lomondside. While Barbara subsequently moved to Groningen in 2018, the appointment of Davide Dominoni in 2019 has continued work with the nest-box populations. Davide's research seeks to uncover the strategies that birds adopt to cope with global environmental change, and the importance of sensory ecology in this context (Dominoni *et al*., 2020). A particular focus of his research is the effects of increasing worldwide urbanisation, to which end he runs a long-term study on blue tits (*Cyanistes caeruleus*) along a 35-mile urban-rural gradient stretching from the centre of Glasgow to SCENE. Using this system, Davide's research group has shown that reproductive fitness of blue tits and great tits (*Parus major*) is greatly reduced in more urban areas, particularly where native trees are less abundant and consequently insect prey are not sufficient to raise healthy offspring. The urban-rural gradient has also been instrumental in demonstrating how light pollution can alter the daily rhythms of activity and physiology in passerine birds, and more recently in owls. Davide is currently involved in a large interdisciplinary project called GALLANT (Glasgow as a Living Lab Accelerating Novel Transformation), with the ultimate goal of his part of the project being to understand how environmental and socioeconomic factors shape the diversity and abundance of bird species, and how urban planning can help ensure the wellbeing of wildlife and humans alike. To this end, he collaborates extensively with other researchers, and with the Glasgow City Council and NGOs.

Research such as Davide's illustrates how science continues to move to more interdisciplinary teams rather than being focused on specific taxonomic groups. Birds are of course interesting from many different perspectives and there is much more work on birds in Glasgow than there is space to mention here. Mike Hansell, an ethologist (see Huntingford, 2024), was particularly interested in things that animals build, and Mike and Maggie Reilly (see Reilly, 2024) established a national collection of bird nests as part of the University's Hunterian Museum collection, a valuable resource available nationally and internationally for research.

A strong link to mathematical approaches to ecology and behaviour was triggered by Graeme Ruxton, who had wonderfully eclectic interests and was on the staff from 1996 till his move to St. Andrews in 2012. In recent years, an increasing diversity of ecologists and behavioural ecologists and mathematical modellers has been appointed, many of whom work in the GKB. Seabird ecology continues to be important, as seabird populations have declined for multiple reasons. Furthermore, shores and near-shore marine areas have become increasingly exploited for renewable energy. The highly connected and dynamically interacting colonial systems typical of seabirds are sensitive to environmental disruption, via collision mortality and displacement disturbance for example, and the causes of their declines are hard to detect and mitigate. Many

scientists in the GKB have worked with conservation biologists to try to address urgent questions that require strong practical and mathematical underpinnings, as well as field research, to develop an accurate predictive reconstruction of the dynamics of species such as the northern gannet (Jeglinski *et al.*, 2023). This multidisciplinary approach has been used to predict, for example, population level responses of seabirds to environmental disruption at a European level. A key area is the development and application of sophisticated mathematical modelling approaches to understand animal spatial distributions, movements and population fluctuations, initially with the appointment of Dan Haydon in 2004, more recently followed by several others, including Grant Hopcraft, Jason Matthiopoulos, Tom Morrison and Richard Reeve, with interests in animal movement and biodiversity measures. The most recent re-organisation of research groups in the new School of Biodiversity, One Health and Veterinary Medicine has resulted in the formation of a large Ecology and Environmental Change Theme, led by Jason. This brings together research into the theory and practice of ecology, going from individual behaviour through to large-scale, long-term ecosystem change (Fig. 2) and also disease dynamics. This integrative approach is essential if we are to rise to the challenges we face from biodiversity loss and climate change.

Fig. 2. The spatial ecology research includes that of Grant Hopcraft and Tom Morrison on factors influencing the large-scale movements of wildebeest in the Serengeti-Mara. (Photo: Daniel Rosengren)

In the late 1980s the Ornithology Group in Zoology established an Ornithology Christmas Lecture and party, which has remained the main Christmas social event in the GKB as the Zoology Department has morphed from a Department, to a Division, then an Institute, and now a School (Downie, 2024). The GKB is full of collegiate and talented people, who both support each other and party together!

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Animal classification and the Taxonomy Initiative

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John Graham Kerr (JGK) was interested in the naming, description, diversity and relationships of living organisms. This interest is seen particularly in his enthusiasm for the proper housing and development of the Hunterian collections, including Fabricius's insect "type" specimens which his colleague R.A. Staig catalogued. Taxonomy in zoology involves the description and naming of each kind of animal. Since the pioneering work of Linnaeus, each newly described kind (or species) has been assigned its own Latin binomial, a name of two words: first, the generic, then the specific, printed in italics, as in *Rana temporaria*, the common frog. The English or common name is how animals are referred to in everyday speech, but they can vary between countries and regions, while the Latin name is universal and allows scientists to be sure of which kind they are dealing with. The specimens used for the first description of any species are known as the "type" specimens and are intended to be carefully curated and catalogued in reputable museum collections. The full Latin name for any species includes the name of the describer: *Rana temporaria* L. denotes that this species' key features were first described by Linnaeus. Although Linnaeus accepted the prevailing dogma of his time that all creatures had been created by God, he and others could see that creation was not random: many species were similar to other species, but distinctly different from others. Linnaeus was therefore able to construct a hierarchy of similarity and difference that allowed the diversity of living organisms to be ordered. For example, *Rana temporaria* is similar to some other frogs, such as the pool frog *Rana lessonae,* but different from another group of frogs with adhesive digital pads, the treefrogs, assigned a different generic name - *Hyla.* While taxonomy is about naming species of organisms, systematics is about the ordering of them into similarity groups. Since the time of Darwin, systematics has aimed to reveal the evolutionary origins and relationships of groups of organisms.

In Glasgow's Department of Zoology, Staig was eventually replaced in 1948 by Roy Crowson's appointment to a University Grants Committee-funded lectureship in taxonomy. Crowson officially retired in 1979 (with no replacement), but continued to work on the taxonomy and systematics of beetles until his death in 1999. The UK had long been a leader in the discovery and naming of species, related to the country's wealth and access to so many colonised countries. Many of the type species discovered by British scientists are kept in the vast collections of the Natural History Museum in London (NHM). However, by the late 20th century, U.K. research in the classification of biodiversity was in decline, especially in universities. In 1992, the House of Lords Select Committee on Science and Technology, chaired by Lord Dainton, published the results of its enquiry into the state of systematic biology research. Its recommendations resulted in two outcomes: the Natural Environment Research Council's (NERC) Taxonomy Initiative (1994-1998) and the Wellcome Trust Biodiversity Initiative (1993-2002). In the NERC scheme, universities were invited to apply for one of three major grants. In Glasgow, Keith Vickerman was still in post as Regius Professor of Zoology, but no longer had administrative head of department responsibilities, and was therefore in a position to coordinate a bid. With the support of the Principal, Sir Alwyn Williams, a paleontologist with interests in taxonomy, Vickerman decided on a multi-disciplinary approach. Glasgow's successful bid (the other two awards went to Reading and Imperial College London) brought together zoologists, botanists, geologists and geneticists: the technology for sequencing DNA was becoming affordable and faster, allowing detailed genetic evidence to inform our understanding of evolutionary relationships.

The NERC grant provided for one lectureship and several research posts. Mark Wilkinson, a specialist on caecilian amphibians and an evolutionary tree theorist, was appointed to the lectureship. Ken Johnson, a researcher on fossil corals and Pete Hollingsworth, a plant taxonomist, occupied two of the research posts. Unfortunately, Wilkinson left Glasgow after a couple of years, for personal reasons, and ended up in the NHM from where he continued to collaborate with Bernie Cohen, geneticist on the Initiative, on amphibian research.

Wilkinson was replaced in 1995 by Rod Page who has remained in Glasgow ever since. Rod is a pioneer in the use of modern computer methods for the establishment of evolutionary trees (his early program TreeView (Page, 1996) has over 12000 citations). He also established a research group on bird louse phylogeny and co-speciation, including an excursion into evidence on human ancestors based on the relationships of lice (Reed *et al.*, 2004). Of early collaborators, Hollingsworth progressed to be Director of Science at

the Royal Botanic Gardens Edinburgh (RBGE); Johnson to be principal researcher at the NHM; Mike Charleston to be professor of Mathematics at the University of Tasmania; Vince Smith to be head of informatics at NHM; and Bernie Cohen continued his research into the phylogeny of marine invertebrates well past "retirement".

The reorganisation of biological science departments that led to the establishment of the Division of Evolutionary and Environmental Biology (DEEB) brought a group of plant ecologists and taxonomists into the Graham Kerr Building, including the University's herbarium, and Jim Dickson of that group was part of the Taxonomy Initiative. Sadly, once they retired, these botanists were not replaced and work on plant taxonomy became very limited. One continuing example is work on begonias. Glasgow Botanic Gardens holds the U.K. begonia collection, and administers the MacIntyre Begonia Trust, which has funded several PhD projects co-supervised by Rod Page and staff at RBGE.

The NERC Taxonomy Initiative was stimulated by the House of Lords report, highlighting the lack of funding and activity in this field. Unfortunately, funding is again scarce, but Rod Page's research continues including collaborations with the Global Biodiversity Information Facility and the Biodiversity Heritage Library, creating websites and Databases on taxonomy.

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History of molecular biology work in the Graham Kerr Building (1996-2024)

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John Graham Kerr's zoology was in a pre-molecular age: his 1917 lectures on *Amoeba* (this volume) indicate scepticism over the value of chemical investigation of how living organisms work. For genetics, this changed in the 1950s with the discovery of DNA's structure and the basis of genetic coding for proteins. Soon, Nobel Laureate Peter Medawar (1965) was able to suggest that although ecologists might not have to engage with molecular biology, good ecologists would. By the 1990s, the increasing availability of DNA sequencing methods at cheaper and cheaper costs generated a huge range of new possibilities for evolutionary biologists and ecologists. However, until the late 1990s, research at the molecular and biochemical levels was concentrated in other areas of the Institute of Biomedical and Life Sciences, such as the Division of Biochemistry and Molecular Biology (DBMB). Integration of DNA techniques with ecology reached Glasgow Zoology in 1996 with the appointment of Richard Griffiths. Griffiths, working at Oxford University, had identified a gene on the W/Z sex chromosomes in birds (equivalent to X/Y in mammals) that had sufficient differences between males and females to provide the basis for a bird-sexing test. The sexes of over 50% of adult bird species and nearly all juveniles are not distinguishable visually. This is a serious problem for conservation programmes where it is important to know the sexes of individuals used in captive breeding and is also a major limit on research into sex allocation in wild populations. Once at Glasgow, Griffiths established a new molecular laboratory staffed by himself, post-doc Bob Dawson and technical assistant Kate Orr (later Griffiths). They quickly developed and published (Griffiths *et al.*, 1998) a rapid, cheap PCR-based test that allowed birds to be sexed from a single drop of blood or piece of feather (Fig. 1). Working with another core technician (Aileen Adam) and a Natural Environment Research Council (NERC) fellow (Iain Barber), they also extended the technique to fish (Griffiths *et al.*, 2000). Given the strengths in ornithology and fish biology, the Molecular Ecology unit was established in the "roof labs" (the floor built on top of the Zoology museum), as a cost recovery-based service primarily for molecular sexing to support other researchers in DEEB but also external partners (for example, from the Centre for Hydrology and Ecology). This service-based model was continued for nearly 20 years after Griffiths left in 2002; it finally came to an end when the COVID-19 pandemic limited access to the laboratories in 2020.

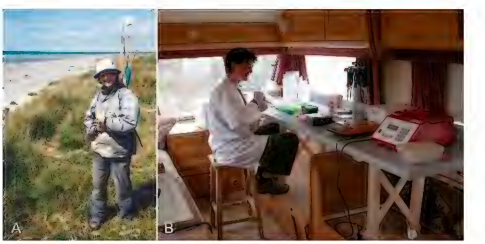

Fig. 1. Sexing gull chicks as part of a study on resource allocation, Walney Island, Cumbria, England. (A) Kate Griffiths carrying a chick to the laboratory. (B) Kate Griffiths in the field molecular laboratory in 2007. (Photos: (A) N. Verboven; (B) R. Griffiths)

The other "big" field that was growing in the 1990s was molecular systematics, which was facilitated both by continuing advances in sequencing technology and in computing power. Known as an innovator in this emerging field, at least partly based on his seminal books on molecular evolution from a phylogenetics perspective (Page & Holmes, 1998) and very widely used programme for visualising phylogenetic trees (Treeview: Page, 1996; cited >13,000 times!), Rod Page was appointed as Reader of Taxonomy in 2001. His initial research in the GKB used phylogenetic approaches to uncover host-parasite coevolution (Page, 2003), but the work was fundamentally about understanding molecular evolutionary processes rather than just using molecular markers as tools for ecology. By the late 2000s Rod had switched his focus more towards biodiversity informatics (Page, 2008) rather than taxon-specific generation of molecular data but the innovation here was to achieve better integration of data from disparate sources.

The next molecular-based researcher to be appointed in the GKB, Lukas Keller, was in Glasgow for only two years (2002-2004) but he formed a critical bridge between the ornithologists in Zoology (which was then the Division of Ecology and Environmental, Biology, DEEB) and parasitologists in the Wellcome Centre for Parasitology (WCP). His primary research interests were in determining the molecular basis of inbreeding depression for conservation, with one of his most cited papers on this topic being published during his time in the GKB (Keller & Waller, 2002). Working with a postdoctoral researcher with expertise in molecular ecology who has remained in the Graham Kerr on various positions until now (Paul Johnson), Andy Tait (WCP) and the NERC biomolecular analysis facility in Sheffield, he also developed new molecular approaches (microsatellite markers) for investigating population genetics of parasitic nematodes in order to understand the impacts of anthelmintic use on red grouse management (Johnson *et al.*, 2006). This work also involved a collaboration with Bill Mullen, a long-term research associate working with Alan Crozier, whose research used innovative approaches to investigate plant hormones and plant products for nutrition. Although he was based in DMDB he moved his laboratory (and his equipment) to the GKB after the Bower building fire in 2001. Together, they used high performance liquid chromatography (HPLC) for metabolite profiling to quantify how much of the drugs the grouse had taken up in order to explain why resistance was not developing as quickly in the bird parasites as occurred when the drugs were used on livestock (Adam *et al.*, 2011).

Integration between molecular evolution, molecular ecology, conservation genetics and host-pathogen interactions was continued when Barbara Mable joined the department, on a Natural Environment Research Council (NERC) advanced research fellowship in 2004. Her original training was in molecular systematics (Hillis *et al.*, 1996) but her postdoctoral research shifted to population and evolutionary genetics. Her main interests focused on molecular evolution of gene families associated with recognition processes, such as host-pathogen interactions in plants and animals and mating system evolution in plants. Prior to coming to Glasgow she had worked on the evolution of whole genome duplication (polyploidy) in microbes (Mable & Otto, 2001), plants (Mable *et al.*, 2004) and amphibians (Mable & Roberts, 1997). However, as the only geneticist in DEEB she became involved with multiple projects on a range of animals, including birds (Neves *et al.*, 2010), fish (Le Vin *et al.*, 2011) and mammals (Marsden *et al.*, 2009), largely through helping PhD students to develop new molecular approaches. Other researchers also continued to use molecular markers as tools to address a range of questions. In collaboration with colleagues in the Division of Infection and Immunity (DII), Douglas Neil, whose research was originally focused on the neurophysiology of crustaceans, developed diagnostic markers to identify pathogens of important aquaculture species (Small *et al.*, 2006). In collaboration with research fellows (François Criscuolo and Pierre Bize) and Kate Griffiths, Pat Monaghan was involved in developing a quantitative PCR (qPCR) assay to quantify variation in telomere lengths in birds, as a marker of senescence (Criscuolo *et al.*, 2009), which transformed the field and led to the establishment of a second molecular biology laboratory in the GKB.

The late 2000s also saw an increase in molecular expertise related to host-pathogen dynamics and epidemiology. In collaboration with the Pirbright Institute, Dan Haydon, a theoretical ecologist and epidemiologist, used whole genome sequencing to make inferences about viral pathogen transmission dynamics, such as tracing the 2001 foot and mouth disease epidemic (Cottam *et al.*, 2006). However, it was not until Roman Biek was appointed in 2007 (funded by a University of Glasgow Kelvin Smith Fellowship in Biodiversity Management) that the expertise for pathogen sequencing became integrated into the GKB. His work lies at the interface of disease ecology and conservation; for example, using phylogenetic approaches to trace transmission dynamics of viruses in wild mammals (Biek & Real, 2010). At Glasgow, initially through collaborative PhD studentships, he also became involved in applied problems related to bacterial pathogens, including bovine tuberculosis (Trewby *et al.*, 2016) and *Borrelia* (causing Lyme disease; Millins *et al.*, 2017), while retaining interests in conservation (Muir *et al.*, 2013). He was also integral to establishing world-leading strengths in rabies virus research when Sarah Cleaveland and Tanzania Lembo (both wildlife veterinarians) moved from Edinburgh to Glasgow in 2008, followed by Katie Hampson in 2009 and Daniel Streicker in 2013 (both of the latter originally supported by Sir Henry Dale Wellcome fellowships but now permanent members of staff). Led by a PhD student who subsequently has been retained on fellowships (Kirstyn Brunker) the team have made innovations in real-time diagnosis of rabies in the field using whole genome sequencing by developing a "lab in a suitcase" approach, opening up new possibilities for diagnostics and transmission tracing (Brunker *et al.*, 2020), and have

made important contributions to understanding transmission dynamic networks for both dog (Lushasi *et al*., 2023) and bat viruses (Jacquot *et al.*, 2022).

During the restructuring of the Faculty of Biomedical and Life Sciences in 2010, DEEB became the Institute of Biodiversity, Animal Health & Comparative Medicine (IBAHCM), integrating veterinary research with ecology and evolution. This involved incorporation of researchers based on the Garscube campus, many of whom were focused on molecular parasitology. However, the restructuring also provided more investment in growth, including vast expansion of molecular capacity. In 2013 the appointment of Colin Selman complemented strengths in life history of ageing by bringing in perspectives from molecular physiology (Mulvey *et al*., 2014). Strengths in genomic approaches to conservation-related problems were enhanced when Kathryn Elmer and Kevin Parsons were both appointed in 2012. They shared interests in ecological speciation of fish (Elmer, 2016; Parsons *et al*., 2015) but also had complementary expertise in developing methods for using reduced representation genomic approaches to investigating population genetics (Recknagel *et al*., 2015) and quantitative genetics related to evolution and development (Parsons & Albertson, 2013). They added capacity to ecological research by the Scottish Centre for Ecology and the Environment (SCENE) director Colin Adams (Crotti *et al.*, 2021) and affiliate Colin Bean (Campbell *et al*., 2017) but also expanded the breadth of questions addressed - Parsons in adaptation to thermal stress (Smith *et al.*, 2024) and Elmer in complex trait evolution in amphibians (Burgon *et al*., 2020) and reptiles (Recknagel *et al*., 2021). A more applied focus to aquatic genomics was brought in with the appointment of Martin Llewellyn in 2015. He developed an artificial system for assessing the impacts of different diets on microbial communities (Kazlauskaite *et al*., 2021), as well as developing innovative approaches for pathogen surveillance in aquaculture settings based on DNA metabarcoding (Peters *et al*., 2018) and genomic approaches for population genetics of parasites (Hernandez-Castro *et al.*, 2017).

The institute also attracted an increasing number of research fellows, many of whom have stayed on for permanent appointments. For example, Francesco Baldini, who initially came on a short-term Italian Leadership fellowship from Perugia University, Italy in 2013, strengthened molecular capacity in the vector ecology group, led by ecologist Heather Ferguson, and developed a novel technological approach for aging mosquitoes based on infrared microscopy (Siria *et al.*, 2022). Expansion of the molecular capacity of the malaria team was supported by the move of Lisa Ranford-Cartwright from the Institute of Infection, Immunity and Inflammation (III) to IBAHCM in 2018 (Mwangi & Ranford-Cartwright, 2013). Additional cutting-edge technological advances have also been brought in by other independent research fellows. For example, another Sir Henry Dale Wellcome fellow, Virginia Howick, introduced single cell sequencing to develop a malarial cell atlas, allowing spatial interpretation of changes in gene expression (Howick *et al*., 2019). There have been ongoing contributions from a wealth of subsequent research fellows, across a range of subject areas funded by the Wellcome Trust, NERC, the Royal Society, the European Research Council (ERC) and the Natural Sciences Engineering Council of Canada (NSERC). As of 2024, nearly all of the fellows in the GKB have molecular approaches as core to their research and from the modest start in the 1990s, at least 23 members of staff in the GKB now use molecular approaches. This rapid expansion has been due largely to increasing technological developments in the scale and power of whole-genome sequencing, but also due to the highly collaborative nature of research within the GKB, enabling combined expertise from the molecular through to the organismal and population levels.

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Student initiatives: the Zoological and Exploration Societies

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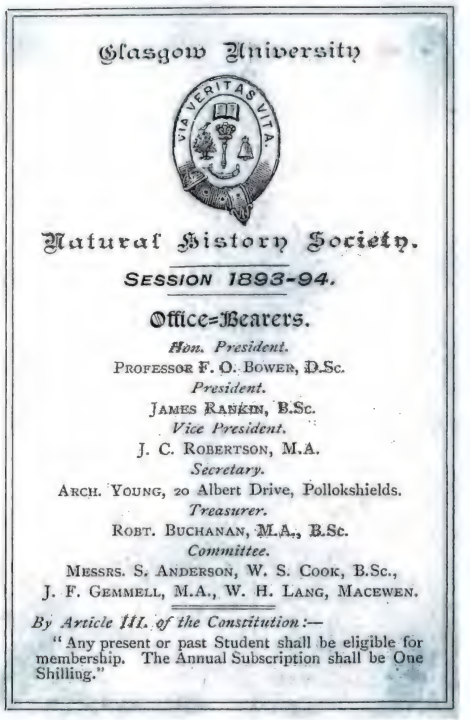
THE ZOOLOGICAL SOCIETY (ZooSoc)

As described in *Gallery of Memories*, JGK became Regius Professor of Natural History in 1902, before the title was altered to Zoology in 1903. The University's archives hold the minute book and a membership card (Fig. 1) of a student Natural History Society for the years 1892-4. Any student, past or present, could join for one shilling. The minutes record lectures by Professor Young (on parasite development) and Professor Bower (on coal plants). As the latter was honorary president, the student society included botany as part of natural history, even though the University's departmental structure did not. The society's secretary regrets poor attendance at excursions (to Possil Marsh, Arran, Ardrossan and West Kilbride) but notes better attendances at lectures, especially those involving kindred groups such as the Natural History Society of Glasgow and the Andersonian Naturalists, with over 100 attending Bower's talk. We do not know if this student society continued into the 20th century, since no records are available. However, Sister Monica Taylor, a pre-World War 1 student, recalls that JGK gave the inaugural lecture to the Zoological Society soon after his arrival in Glasgow. It is likely, therefore, that the student society split when the separate chairs in Zoology and Geology were inaugurated and that ZooSoc dates from 1903.

The first ZooSoc archives record is the minute book covering sessions 1926-7 to 1935-6. This notes that the "new" ZooSoc was established on 21st May 1926. However, the accounts show a carry-over of £2 from 1924-5. The most obvious interpretation is that ZooSoc temporarily collapsed in 1925, and was resurrected in 1926: with student numbers small, and the traumas of World War 1 only recently over, running a student society may well have been difficult. Irrespective, it is clear that ZooSoc has continued since the 1926 re-birth (although actual archives are sparse; note to the present Society: please keep minute books and other records!). By 1926, the membership cost had risen to two shillings and sixpence. ZooSoc's aims were "to promote interest in zoology by discussions, papers on zoology and excursions to places of zoological interest". The Society met on Friday afternoons at 4.00, with tea followed by a



Glasgow University

VIA VERITAS VITA

Natural History Society.

SESSION 1893-94.

Office-Bearers.

Hon. President.

PROFESSOR F. O. BOWER, D.Sc.

President.

JAMES RANKIN, B.Sc.

Vice President.

J. C. ROBERTSON, M.A.

Secretary.

ARCH. YOUNG, 20 Albert Drive, Pollokshields.

Treasurer.

ROBT. BUCHANAN, M.A., B.Sc.

Committee.

MESSRS. S. ANDERSON, W. S. COOK, B.Sc., J. F. GEMMELL, M.A., W. H. LANG, MACEWEN.

By Article III. of the Constitution:—

"Any present or past Student shall be eligible for membership. The Annual Subscription shall be One Shilling."

Fig. 1. Membership card for the Glasgow University Natural History Society, 1893-94, listing the office-bearers.

lecture or other activity. Reflecting the preponderance of medical students among the membership, lectures were often on biomedical topics. For example, the inaugural lecture in 1926 was given by J.S. Dunkerley on protozoans: Dunkerley moved to Manchester as professor around that time, and was a specialist on flagellate protozoans, including trypanosomes. A highlight each year was the Inter-University Biological Conference, first recorded from February 1927 and held that year over two days in St. Andrews. Glasgow sent 14 delegates. Professor D'Arcy Thomson chaired the lecture sessions and there was a dinner dance on the Friday night. Joint meetings with other societies often featured, sometimes including a debate: in December 1932, ZooSoc, the Botanical Society and the Physical Society debated the proposition "That scientific progress in the future will be biological rather than physical": the biologists won (were they right?). During the 1930s, the programme included several meetings each year devoted to student papers (six in 1934-5). These were intended to encourage research by students (the Honours curriculum at that time did not include a research project), but turned out to be unpopular, since the students lacked facilities, resources, time and supervision, making it hard for them to do any worthwhile research. The ZooSoc logo (Fig. 2) appeared in the 1930s, designed by A.J. Haddow: he was Society secretary 1932 to 1934, when he graduated, progressing

Fig. 2. Zoological Society logo from the 1934-35 membership card, incorporating a representation of the Graham Kerr Building's front-door knocker's snake, drawn by A.J. Haddow.

to a distinguished career in African sleeping sickness research. He was also a skilled artist: his drawings of African primates are displayed in the GKB's upper corridor. After World War 2, as zoology student numbers increased, so did ZooSoc membership. In 1967-8, it was 493, making it one of the largest student societies in the University. After the creation of Biology-1, with first year students taught in the Boyd Orr Building, it was hard to attract junior students to ZooSoc and numbers did not reach those heights again. The Inter-University Biological Conferences continued until the late 1960s but became too difficult to organise, once student numbers had mushroomed, the subject had diversified, and new universities had joined the original four "ancients". Another joint enterprise was the Scottish Universities touring speaker in biology, where a distinguished scientist addressed the students of each of the four ancient universities over a single year. Speakers included Sir Alister Hardy, Sir Peter Medawar and John Maynard Smith, but this scheme too became difficult to organise and was discontinued in 1969.

In its 98th year, the Society continues to bring together students with a shared enthusiasm for the natural world. In 2023-4, ZooSoc boasts a membership of 150 and recently hosted the University of Galway ZooSoc, and introduced them to the GKB. Over recent years, ZooSoc has welcomed a range of speakers such as Helen Taylor of the Royal Zoological Society of Scotland, Francesca Trotman of the not-for-profit organisation *Love the Oceans*, and Jill Mackay, author of *Animal Personalities*. In this session, there has been an increase in conservation efforts involving ZooSoc, including close collaboration with the Glasgow University Environmental Sustainability Team on beach cleans,

litter picks, Bioblitz events, and rewilding sessions at the University's wildlife garden.

THE EXPLORATION SOCIETY (ExSoc)

As recounted in *Gallery of Memories*, JGK's interest in remote field research stemmed from his time as a naturalist on a river-mapping expedition in the Gran Chaco region of South America, and his follow-up five years later to collect lungfish embryos in the company of his colleague Budgett who was researching amphibians. Once he became Regius Professor at Glasgow, JGK made no further overseas expeditions himself, although colleagues pursued related work in west Africa and South America. There is no evidence that JGK encouraged students to undertake expeditions themselves, although he was keen to enthuse them with accounts of his own adventures.

The first student-run biology-based field expedition from the University of Glasgow that we know of was to the Inner Hebridean island of Canna in 1936, followed by a repeat in 1937, with the expressed intention that more would follow. World War 2 then intervened, and the next expeditions were to the Garvellach Islands in 1949 and St. Kilda in 1956. There does not appear to have been any established society organising these expeditions. Instead, interested students with the help of staff devised a plan, then applied for support from the University Court.

In the late 1950s, with overseas travel becoming easier and cheaper, the Royal Geographical Society introduced an expedition grant scheme (1956), and the Carnegie Trust for the Universities of Scotland (1959) brought in a similar scheme for Scottish University expeditions. In the 1960s, ten expeditions took place, two in Scotland, and eight elsewhere in Europe. We do not have records of when the University of Glasgow ExSoc was founded but we know that it supported three expeditions in 1970 (Finland, Calabria - both geographical; and Morocco - mainly zoological), with Morocco being the first outside Europe. During the 1970s, 20 expeditions were organised, five to Scottish locations, 15 elsewhere, including one to the Seychelles, the most distant location so far.

During this period, the ExSoc committee was mostly composed of Zoology or Earth Science students, with expeditions focused on one or other discipline, although Iceland 1972 was a good example of an interdisciplinary expedition, being undertaken by geologists and zoologists. Topographic science expeditions were essentially fieldtrips aimed at providing final year students with opportunities to collect data for their dissertations. The Carnegie Trust eventually made clear that this was not what their support was for: data for a dissertation could be collected on an expedition, but that was not to be the sole aim. Only seven expeditions (three in Scotland; four elsewhere) ran in the early 1980s, and ExSoc seemed to have run out of steam. However, in March 1988, a group of staff and students held a preliminary discussion about resurrecting ExSoc and this was achieved at a revival meeting on 12th May (Fig. 3), leading to the writing of a constitution and the establishment of an Exploration Council (a group of experienced academics, initially chaired by Professor Ian Thomson of Geography), whose role was to oversee the activities of the Society. A key part of this was the allocation of University grants to approved expeditions: approval and funding by the University was crucial in applying for grants from organisations like the Carnegie Trust. The revival of ExSoc was helped by the fact that the Principal of the University, Sir Alwyn Williams, was a field geologist who strongly believed in the importance of fieldwork for student development. The first expeditions under the new system were in summer 1989 to Trinidad and Tobago, and to the Azores. Both were biological in their aims, mostly zoological but with some botany.

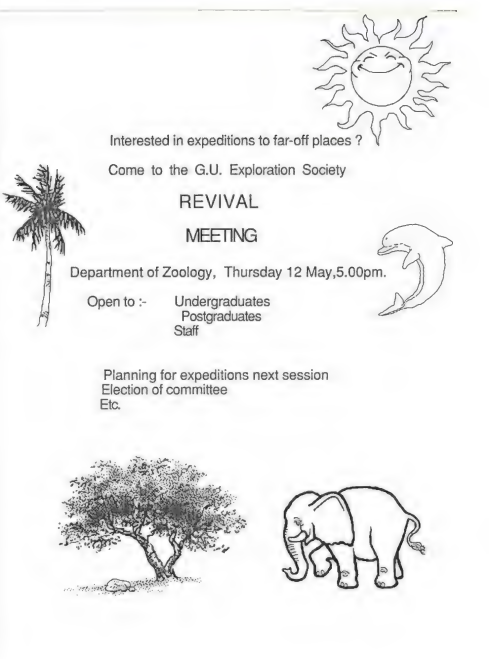


Fig. 3. Poster used to attract interested people to the Exploration Society revival meeting in 1988.

In the 36 years since ExSoc's revival there have been 199 expeditions, 5.5 per year, including the hiatus years of the COVID-19 pandemic: there were no expeditions in 2020, and a very limited set in 2021 - Iceland and a set of Scottish locations. However, 2023 saw a full return to ExSoc activity with expeditions to Harris, Egypt, Iceland (Fig. 4), Guyana, Thailand and Tobago (Fig. 5). Table 1 shows the locations of expeditions by world region.

ExSoc's website holds the reports of a large number of expeditions. The University Library also holds many pre-digital reports, and there is a plan to store other ExSoc documents in the University's archives. Several papers have been published on the achievements of

Location	Number (%)	Notes
Scotland	9 (4.5)	Mainly Islay, Harris
Europe	53 (26.6)	Mainly Cyprus, Iceland
Africa	32 (16.1)	Mainly Egypt
Asia	13 (6.5)	Thailand, Sri Lanka, Malaysia etc.
Australasia	2 (1.0)	
North America	1 (0.5)	Canada only
South America/Caribbean	89 (44.7)	Mainly Trinidad, Tobago and Guyana

Table 1. Principal locations of University of Glasgow Exploration Society expeditions, 1989- 2024.

Fig. 4. Arctic fox den surveying on the Iceland expedition, 2023. (Photo: ExSoc)

Fig. 5. Bat surveying on the Tobago expedition, 2023. (Photo: ExSoc)

UG ExSoc: Downie *et al.* (2008) discuss the potential for expeditions to provide opportunities for final year research projects; Downie *et al.* (2016) analyse the natural history contributions of expeditions, up to 2016; and Harper *et al.* (2017) discuss the impacts of expeditions on student development. ExSoc is a University-wide institution, open to all: recent expeditions have included students of Psychology, Geology, Geography, Mathematics and Immunology. However, the biggest contributions to its activities have been by zoologists and marine/freshwater biologists, both staff and students, and ExSoc has close interactions with ZooSoc.

As the expeditions are student-led with minimal staff supervision, they require students to gain and develop a wide variety of skills: fund-raising, grant writing, organisation and teamwork. Successful grant applications have gained funds from The Explorer's Club, Glasgow Natural History Society, the Lord Mayor's Trust, the Fisheries Society of the British Isles and many others. Students have also won awards for the work done on expeditions: in 2023, a student on the Egypt expedition won the Guild of Freemen's Prize from the Lord Mayor's Trust; in 2024, an Iceland expedition student was selected to give a research presentation at the Explorer's Club headquarters in New York. The Society provides expedition leaders with training, and all those selected to join an expedition take part in training of various sorts, especially on fieldwork health and safety. In 2024, ExSoc had 137 members and a record number of applications to join expeditions, a sign of excellent health.

Many former ExSoc members have progressed to masters and PhD degrees, and then to field, ecological and conservation research and activity. They look back fondly to their time in the Society, and regard the expedition experience as influential in guiding them towards their current careers.

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Marine biology research for the last 50 years

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The Department of Zoology, University of Glasgow has been active in marine biology research for the last 50 years, and earlier with Sir C.M. Yonge's significant contribution to this field. This article outlines the work of several staff members who have made important research contributions in this field. Some are described only briefly because their work is also covered in other articles.

In 1963, Peter Meadows was appointed as a lecturer by Yonge. Peter had worked as a research assistant at Menai Bridge Marine Laboratory under Dennis Crisp, looking at the chemical basis of gregarious settlement of barnacle larvae. Even though Peter did not have a PhD, this ground-breaking research facilitated his appointment as a permanent lecturer at the University of Glasgow. From 1964 to 1980s Peter and his co-workers' research largely focused on habitat (substrate) selection by the marine amphipod *Corophium volutator* (Pallas), resulting in joint publications with John Anderson and Janette Campbell. A textbook on marine science was published (Meadows & Campbell 1978,1988). Peter and his more than 30 postgraduates (many from the Middle East and South Asia, including Azra Tufail, whom he later married) engaged in research from 1980 onwards that moved on to investigate marine sediment-benthos interactions - bioturbation of burrowing invertebrates and microorganisms (Fig. 1). The focus was on mucus secretions which bind sand grains together and help stabilise the sediment, under laboratory and field conditions, both in the intertidal zone and the deep sea. In 1980s Peter established the Biosedimentology Unit in the Zoology Department. This led to interdisciplinary collaboration with engineers at the University of Glasgow, measuring the sediment strength of the mucus stabilising effect of organisms as ecosystem engineers. Peter and his co-workers received a medal from the Institution of Civil Engineers for this pioneering work in 1995. He was a keen SCUBA diver. He participated in several deep-sea research cruises in the Atlantic, Pacific, and Indian oceans, examining the effects of bioturbation, geotechnics, and microbiology at the sediment-water interface and below. A symposium on the impact of burrowing animals was published as Meadows & Meadows (1991). From the early 1990s onwards, Peter and Azra Meadows (now an Honorary Senior Lecturer) and collaborators conducted research on coastal zone management and sustainable development of rural communities in Pakistan. These

Fig. 1. Peter Meadows in his fieldwork clothes collecting at Ardmore Point, Clyde Estuary. (Photo: Azra Meadows)

communities' livelihoods depend on artisanal fisheries and mangrove swamps (Fig. 2). An outcome was a symposium and publication of the proceedings (Meadows & Meadows, 1999). Peter and Azra, together with Professor Israr-ud-Din of the University of Peshawar, led the Royal Geographical Society-funded multidisciplinary 1999 International Hindu Kush Expedition to Chitral, Pakistan. In 2005 Peter was awarded a civilian award "Sitara-i-Quaid-i-Azam" (= Star of the Great Leader, Mohammad Ali Jinnah), by the Government of Pakistan for services to education and the environment. Azra and Peter were invited as consultants by the Asian Development Bank in 2006, to advise on the biological and environmental aspects of the six-year (2007-13) "Sindh Coastal Community Development Programme" with a loan of US$36 million to the Government of Pakistan. In 2010 The Scottish Government funded their two projects with collaborator Yasmeen Lari on natural disasters, preparedness, and rehabilitation in Pakistan. A key output was the publication of a manual on disaster preparedness (Lari *et al.*, 2013). Peter with his co-workers published over 150 research papers and he retired in 2001 but remained active as an Honorary Lecturer until his death in 2023.

Peter Spencer Davies was a marine biologist at the University of Glasgow from 1962 until 1999, where his special interest was in the physiology of tropical coral

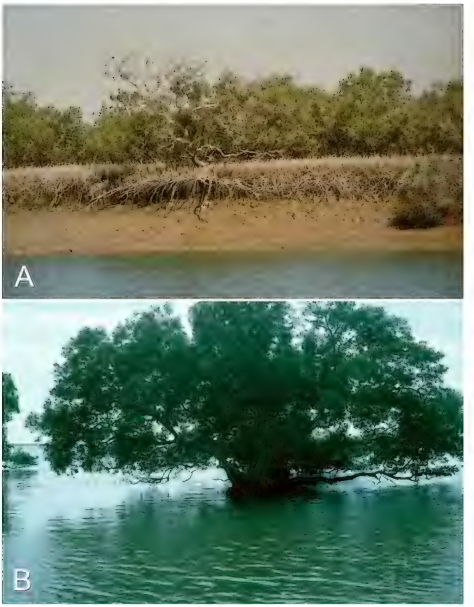

Fig. 2. Mangrove swamps in Sindh, Pakistan. (A) Unhealthy mangroves at low tide, showing erosion. (B) Healthy mangroves, high tide. (Photos: Azra and Peter Meadows)

He and his collaborators including Keith Vickerman, studied the infection of Norway lobster (*Nephrops norvegicus*) in the Clyde Sea Area by the parasite *Hematodinium* spp., an endoparasitic dinoflagellate that causes morbidity and mortality. Alan Taylor (1978-2014) was a comparative respiratory physiologist working on marine invertebrates. The work of Davies, Neil and Taylor is covered by Neil (2024).

reefs. Douglas Neil joined in 1975 and retired in 2012. Robert Furness's main interest is seabird ecology: he joined in 1978 and retired in 2018 as Professor of Seabird and Fishing Interactions. He has published over 300 scientific papers and supervised over 55 PhD students. After retiring, Bob was appointed Principal Ornithologist at the environmental consultancy MacArthur Green, focusing on the impacts of offshore wind farms on seabirds.

Marine turtle studies had three origins. First, Roger Tippett and his wife Sally Solomon, who worked on avian egg-shell structure and hatchability, were asked in the late 1980s to help the Cayman Islands green turtle hatchery with their problems in achieving hatching success. Second, the first Trinidad expedition (1989) included a team assessing leatherback turtle nesting, and threats to it on Trinidad's east and north coasts. Then Tippett and Solomon were asked to help a small non-governmental organisation in North Cyprus which was attempting to monitor loggerhead and green turtle nesting success on many small beaches. From these beginnings grew the long-term North Cyprus marine turtle research programme, now run from the Penryn, Cornwall campus of Exeter University after Glasgow graduates Brendan Godley and Annette Broderick (both now Professors) moved there. There have also been multi-year turtle studies in Trinidad and Tobago. Both projects have generated many research papers and theses on a wide range of topics in marine turtle biology and contributed to an upturn in turtle fortunes at those locations. Annette Broderick writes: "The opportunity to participate in the Trinidad expedition gave me the marine turtle experience that was the basis of my career! If I had not been chosen to go on that trip, who knows where I would be right now?" Additional Glasgow staff involved have included Bob Furness, Roger Downie, and Malcolm Kennedy.

David Bailey was appointed as a lecturer in 2007. He came from the Scripps Institution of Oceanography in California where he had been a Marie Curie Outgoing Fellow. Although he had worked on conservation issues in the past, he was mostly doing deep sea physiology and ecology at that point. Pretty much straight after landing in Glasgow he was invited to join a Scottish Government "task force" on the state of the ecosystems of the West Coast of Scotland. With this background, and accidentally discovering that deep-sea fisheries were having a massive impact on fish communities, he ended up working thereafter mostly on conservation. Since 2007, David, his 13 postgraduate students and postdocs have done fieldwork and published about Angola, Antarctica, Atlantic deep sea, Australia, Bahamas, Bangladesh, Canada, Egypt, Mauritius, Mozambique, New Zealand, Indonesia, Scotland, and Spain. With relentless and foolhardy optimism, David and his team try to provide useful science to support conservation. They have had some successes on the regulation of fishing in the deep sea, and on protection of cod spawning here in Scotland. David maintains "There's a lot more to do on understanding and protecting essential fish habitat and helping improve conservation policy here and with our overseas partners."

Dominic McCafferty started working in 1999 as a lecturer in the Department of Adult and Continuing Education and was an Honorary Research Associate in DEEB. He joined IBAHCM in 2012. Dominic's main areas of research are thermal physiology of pinnipeds and seabirds. Some of the major research projects and collaborations undertaken so far include the energetics of moulting elephant seals, and collaborations with French scientists on an assessment of invasive research procedures on marine mammals. He has conducted elephant seal whisker and seabird carrion stable isotope analysis.

Anna McGregor was appointed as a Teaching Fellow in 2012 and she is now a Senior Lecturer. Her research background focuses on the use of sound in marine mammals and the potential for anthropogenic noise to cause physiologically relevant disturbance. More recently, Anna's work has included studying the effects of noise on other animals as well as those in aquatic environments, and the use of acoustics to monitor cryptic animals in a number of habitats. Her other

research projects are on cross-disciplinary approaches to determining habitat suitability for native oysters, and phenological synchrony in temperate terrestrial soundscapes.

Sofie Spatharis joined as a lecturer in 2013 and is now a Senior Lecturer. She is a community ecologist and specialises in phytoplankton diversity. Her research interests also cover coastal water quality and conservation such as the impact of pollution on coastal communities and the impact of harmful algal blooms on coastal seaweed and finfish aquaculture. Sofie's research includes dynamic modelling, hypotheses testing using laboratory microcosms, field mesocosms and field sampling in both in-situ biodiversity experiments with phytoplankton microcosms in incubators. Her team also tests for the effects of stressors such as artificial light and microplastics on ecosystem services provided by marine bivalves. Sofie is particularly interested in the role of temporal fluctuations of resources on the emergence of species-rich assemblages and the relative role of niche over dispersal processes in shaping phytoplankton composition, and in microalgal metabolomics and genomics. Her eDNA work with Martin Llewellyn, on salmon and seaweed aquaculture pathogens, is having direct impact on the Scottish aquaculture industry.

The Scottish Marine Animal Stranding Scheme (SMASS) began in 1992. It gathers, collates, analyses and reports data on all cetaceans, seals, marine turtles and basking sharks that strand on the Scottish coastline. After a tendering process, SMASS moved to the University of Glasgow from 2021, with its Director, Andrew Brownlow, becoming a Senior Lecturer in Veterinary Epidemiology. As this article was being written (July 2024), a particularly serious stranding event occurred when 77 pilot whales died on the shore of the Orkney island of Sanday. SMASS staff were quickly on the scene to carry out post-mortems and to gather as much evidence and data as possible.

Laurence De Clippele was appointed lecturer in mid-2023. Her main areas of research are marine ecology – spatial and temporal patterns in biodiversity using machine learning methods on image and acoustic data. Her current research projects include passive acoustic monitoring as a tool for offshore wind farm biodiversity assessments.

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Physiology and neurobiology in the Graham Kerr Building

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The study of animal physiology in the Graham Kerr Building (GKB) began with the work of James D. Robertson (universally known as "JD") (in post 1946-1982). His careful analyses of the blood composition of invertebrates and lower vertebrates led him to develop a hypothesis of chordate evolution (Robertson, 1957). In the 1960s he was joined by Peter Spencer Davies (1962–1999), who developed methods to measure the energy budgets of corals in relation to their symbiotic relationship with photosynthetic algae (zooxanthellae). This work paved the way to understanding how environmental changes impact coral reef growth. Later, Alan Taylor (1978–2014) joined the physiology group, bringing expertise in measuring respiration rates of a range of aquatic invertebrates, especially those with a burrowing life-style.

Research on brain and behaviour began with Otto Loewenstein, then Graham Hoyle from 1939 onwards (Yonge in Downie, 2024). In the 1960s Peter Usherwood (1960-1974) established a new line of research using electrophysiological techniques to study the neuronal and pharmacological processes in large insects such as locusts, before leaving for a chair at the University of Nottingham. However, through the 1970s the electrophysiology (later called neurobiology) group actually enlarged through the arrival of Jon Barnes (1966-2006), Martin Burns (1970-2000) and Douglas Neil (1975–2012). Their studies now included work on decapod crustaceans, with Jon examining the control of walking in crabs and crayfish, Douglas investigating swimming in lobsters and shrimps, and Martin providing expertise in electronic instrumentation and data logging to underpin these investigations.

In the 1970s the Physiology and Electrophysiology groups each gained their own laboratory facilities in the GKB, but these disrupted the original layout of the Zoological Museum. The Roof Laboratory for

physiological studies was constructed over the skylights of the Museum, and an Electrophysiology Unit (EPU) was established by Peter Usherwood in what had been one of the side galleries of the Museum. These two laboratory facilities were managed by two of the Department's most reliable technicians, Cathy McLagan and Don Little, respectively. To improve the facilities for holding marine animals in the Department, mainly for physiological studies, a circulating seawater system was established in the GKB in the late 1970s, with a large (8,000 gallon) holding tank in the yard, filter and header tanks installed in the loft space above the main Lecture Theatre (LT1), and gravity-fed supplies of seawater to the main laboratories and to two refurbished marine aquaria in the basement.

Unfortunately, on the night of Friday 19th February 1988 a severe fire broke out in the Roof Laboratory, apparently due to an electrical short-circuit. The prompt action of the Glasgow Fire Service prevented it from spreading to the rest of the building, but there was severe fire damage to the laboratory facilities and to the physiological equipment housed in the Roof Laboratory. Fortunately, the laboratory record books that contained valuable experimental data survived. However, as a result of the amount of water needed to douse the flames, there was extensive collateral water damage to the Museum below, including the EPU. The Roof Laboratory space was eventually refurbished as a series of smaller laboratory spaces to house facilities for molecular and cellular research, while the physiologists were re-housed in other parts of the GKB.

Physiological methods were later applied by Peter and Alan to a wider range of animals, particularly through their collaborations with fish biologists both in the GKB and elsewhere. Meanwhile, Martin designed electronic equipment for many other purposes than neurobiology, including the remote data logging of the temperature and the weight of eggs in bird nests, to assist the researches of the ornithology group.

Martin and Peter eventually left the university to pursue careers in instrumentation research and development. However, they left a legacy of numerous sophisticated practical exercises that have continued to be performed by level-3 students in Animal Physiology classes up to the present day. Following the formation of the Institute of Biomedical and Life Sciences in 1994, when the Zoology Department became the Division of Environmental and Evolutionary Biology (DEEB), Jon Barnes transferred to the Centre for Cell Engineering, having changed his research focus to the biomechanics of adhesion in the toe pads of amphibians (Jon died in spring 2024 as this article was under preparation). Douglas Neil had a brief sojourn in the Division of Neuroscience and Biomedical Systems, before returning to DEEB, and Alan Taylor became heavily involved in the administration of the Institute. Around this time, the EPU was converted to an open area housing a large computer cluster for use by undergraduate and postgraduate students.

Douglas's research developed from studies of the neuronal control of the swimming performance of commercially important crustaceans such as lobsters (*Homarus gammarus*) and langoustines (*Nephrops norvegicus*), to examining their muscle properties, and eventually to relating these to the quality and preservation of the seafood products derived from them. From the mid-1980s he was also involved with colleagues in the GKB, particularly Professor Keith Vickerman, and with Jim Atkinson at the University Marine Biological Station Millport (UMBSM), in an interdisciplinary study of a parasitic infection of langoustines in the Clyde Sea Area (Fig. 1). A review paper and two data archives from this extensive 30-year study have now been published (Molto-Martin *et al.*, 2024).

Fig. 1. Grant Stentiford, then with Douglas Neil's research group, making an assessment of the extent of infection of langoustines (*Nephrops norvegicus*) in 2001. Professor Grant Stentiford is now Chief Scientist at the Centre for Environment, Fisheries and Aquaculture Science (Cefas), Weymouth, which is an Executive Agency of DEFRA. (Photo: D.M. Neil)

Most recently, physiology in the GKB has moved in a new direction, following the appointment of Colin Selman who studies the mechanisms underlying the process of ageing, particularly in mammals but also, in collaboration with Pat Monaghan, in birds.

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The Flourishing of Glasgow Zoology: roots of a celebration, and thoughts on the future

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A few years ago, Maggie Reilly, Pat Monaghan and Roger Downie had mooted the idea of a celebration of zoology at the University of Glasgow, in the context of 2023 as the centenary of the opening of the Zoology (now Graham Kerr) Building in 1923. Discussions began in early August 2022, around the idea of publishing John Graham Kerr's memoir as the core of a centenary publication. The Glasgow Natural History Society (GNHS) agreed to fund this and produce it as a supplement to *The Glasgow Naturalist* in recognition of the close ties between the Zoology Department and the Society.

Over the next year, an organising committee (Roger, Maggie, Regius Professor Pat Monaghan, Professor Neil Metcalfe, Mike Rutherford (Zoology Museum curator), Jennifer Crawford (School administrator), Zara Gladman (Public and Community Engagement Manager) and representatives from the Estates Directorate) met several times to develop a programme of celebration events.

£2-3K funding from the College of Medical, Veterinary and Life Sciences was obtained and GNHS also agreed to fund refreshments. The Estates representatives described the extensive refurbishment work taking place in the foyer and the teaching laboratory over summer 2023: these works were planned to be completed by September and should therefore not interfere with the celebrations planned for the autumn. Table 1 shows the components of the celebratory events and activities on 16th September, 30th November and 5th December 2023.

Attendance at the Doors Open Days event on 16th September was 180. In the run-up to 30th November, there was some concern over numbers and it was agreed that representatives of undergraduate student societies could attend, but that other undergraduates would be invited to attend the 5th December lecture. With current and past staff and postgraduate members, Lecture Theatre 1 was full on 30th November (Fig. 1), and the reception in the museum packed and greatly enjoyed (Figs. 2-5). The 5th December lecture in the Boyd Orr building was also well attended and enjoyed.

For the centenary publication, the original plan was that it would be launched at an event during the Glasgow Science Festival in June 2024. As work progressed, the scope of the publication expanded, as it became clear that this would be a once in a century opportunity to assess the work done in the department and to reflect on its impact and all the people who had contributed. News came that a major refurbishment of the main lecture theatre was to take place during summer 2024, and so the launch of the publication was postponed until 21st September 2024 where it could be linked to a second Open Doors Festival event. The 2024 Open Doors theme - *We're all here: diversity and diaspora* - was an excellent fit with the modern Zoology department with its focus on biological diversity and its origins, and its

1. Glasgow Open Doors Days Festival (16th September): guided tours of the Graham Kerr Building, plus family activities on animal senses in the Museum.
2. One Hundred Objects: a continuous slide show in the Zoology Museum of selected specimens from the Hunterian zoological collections, illustrating their diversity and history.
3. Celebratory event (30th November):
   a) Four short lectures in Lecture Theatre 1 (Fig. 1), introduced by Head of School Chris Loughrey:
   Roger Downie - The Graham Kerr Building: Centenary 1923-2023.
   Nick Haynes - University of Glasgow, Centenary of the Zoology Building.
   Pat Monaghan - Evolution of Zoology in the Graham Kerr Building: Adaptation, Drift, Polymorphisms, Hybridisation, Extinctions, Environmental Change and Catastrophes.
   Roman Biek - Zoology Research at University of Glasgow: Into the Future.
   b) Reception in the Museum (Fig. 2), including a cake competition (eaten after judging) (Fig. 3), a special celebratory beer produced by Loch Lomond Brewery (Fig. 4), buffet and drinks, and music by departmental band Black Fox.
4. Centenary Lecture (5th December): Roger Downie - Sir John Graham Kerr and the Flourishing of Glasgow Zoology. Part of Glasgow Natural History Society programme.
5. Centenary T-shirt & hoodies (design by Mike Rutherford, incorporating a picture of the building's snake door-knocker) for sale (Fig. 5).

Table 1. Centenary Celebration, Autumn 2023.

Fig. 1. Panoramic view of the Lecture Theatre 1 event, 30th November 2023. (Photo: Andy Wilson)

Fig. 2. Celebrators in the Museum, 30th November 2023. (Photo: Andy Wilson)

Fig. 3. Example of a celebratory cake. (Photo: Andy Wilson)

Fig. 4. The specially designed label for the centenary beer.

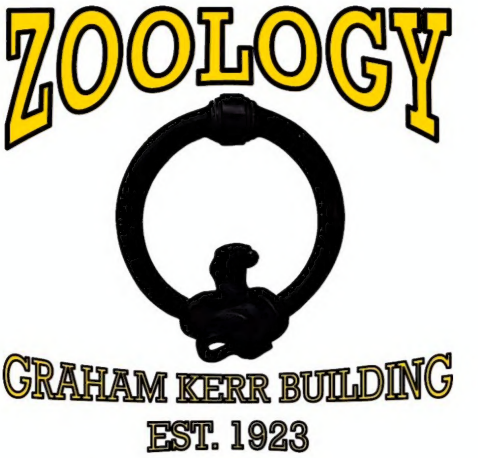

Fig. 5. Mike Rutherford's T shirt design.

international reach (Figs. 6-8). The publication has developed into a substantial book, with several sections (Table 2). The section on the department during the last 50 years was originally intended to provide a short overview but expanded to include articles on the very varied research and teaching activities and developments, and on the people involved. It was very gratifying to find how willing some very busy people were to write on the history of the department's involvement in their area of expertise.

Fig. 6. The 2024 Open Doors organising team at the Graham Kerr Building entrance: from the left, Martha Stone-Shepherd, Emma Plant, Roger Downie, Maggie Reilly and Mike Rutherford. (Photo: University of Glasgow Photographic Unit)

1.	A Gallery of Memories: Sir John Graham Kerr's memoir, with an introduction and notes by Roger Downie and illustrations arranged by Maggie Reilly.
2.	Dr Flo's Lecture Notes: John Graham Kerr's Lectures on Protozoa as recorded by Flora Livingstone, 1917, with a commentary by Stephen Phillips and biographical note by Alasdair Whyte.
3.	University of Glasgow Department of Zoology 1923-1973: reprint of articles from 1973 pamphlet with notes by Roger Downie.
4.	The Department of Zoology and the Hunterian Zoology Museum, by Maggie Reilly.
5.	The Flourishing of Glasgow Zoology: 20 articles by multiple authors on different aspects.

Table 2. Sir John Graham Kerr and the Flourishing of Glasgow Zoology: main sections of the supplement.

Fig. 7. Lydia Bach and daughter finding out about oysters from Anna McGregor, right. (Photo: University of Glasgow Photographic Unit)

Fig. 8. Maggie Reilly describing features of the newly refurbished Graham Kerr teaching laboratory to Open Doors visitors. (Photo: University of Glasgow Photographic Unit)

A website on the history of Glasgow Zoology is also being developed where it will be possible to include the many more photographs, and other illustrations discovered during research, than could be included in the printed publication. The website is intended to be augmented as more information comes to light.

What of the future? On our educational role, it is unlikely that the fascination of young people for the natural world will wane, and there will therefore continue to be a demand for a sound education in all aspects of biodiversity. How new technology will influence the delivery of higher education in the future is under debate, but we think that the place for interaction with enthusiastic, innovative and knowledgeable communicators is unlikely to disappear.

On our research role, the last few decades have demonstrated the crucial place of investigation into how the natural world works and how human activity can damage it. The COVID-19 and bird flu pandemics are two examples where Glasgow Zoology has had an impact: the "One Health" strand of our teaching and research will remain vital. The climate and biodiversity crises are also areas where our teaching and research are important, through local, national and international contexts. The work of SCENE is part of this, and also the recently-begun interdisciplinary ten-year project GALLANT (Glasgow as a Living Lab Accelerating Novel Transformations), which aims to deliver a resilient city through a city-university partnership.

Can we foresee any changes? After recent history, another departmental re-organisation cannot be ruled out. But more usefully, perhaps, we think there is unfulfilled demand for attention to plant, fungal and microbial diversity, given the close interactions between animals and these lifeforms. Renewed focus on these organisms would broaden and enhance the existing highly successful studies on molecular aspects of plant function.

ACKNOWLEDGEMENTS

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The Glasgow Naturalist

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1. *The Glasgow Naturalist* publishes full papers, short notes and book reviews. All articles are peer reviewed by a minimum of two reviewers. The subject matter of papers and short notes should concern the natural history of Scotland in all its aspects, including historical treatments of natural historians. Details of the journal can be found at: www.gnhs.org.uk/gnat.html

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4. References should be given in full according to the following style:

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O'Reilly, M., Nowacki, S. & Gerrie, E. (2018). New records of the white-banded grapple-worm. *The Glasgow Naturalist* 26(4), 96-97.

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References with more than six authors: name the first six authors, then add "*et al*."

5. References should be cited in the text as follows:

Single author: Pennie (1915)… (Pennie, 1915). Two authors: Grist & Bell (1996)… (Grist & Bell, 1996). More than two authors: Smith *et al.* (2009)… (Smith *et al.*, 2009). Multiple citations: (Pennie, 1915; Grist & Bell, 1996). Same author(s), publications in different years: (MacGillivray, 1840, 1855).

6. An organism's genus and species names should be given in italics when first mentioned. Thereafter only the common name is required. Please use lower case initial letters for all common names, e.g. wood avens, blackbird, unless the common name includes a normally capitalised proper name, e.g. Kemp's ridley turtle. The nomenclature of vascular plants should follow Stace, C.A. (2019). *The New Flora of the British Isles*. (4th edition). C&M Floristics, Stowmarket. Normal rules of zoological nomenclature apply. When stating distribution, it may be appropriate to give information by vice-county.

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